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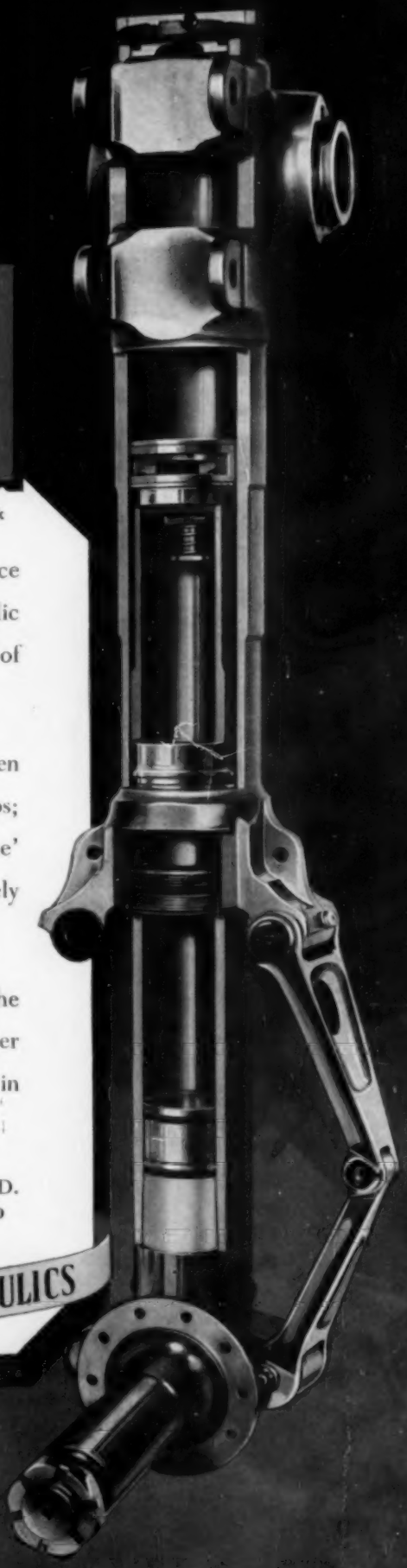

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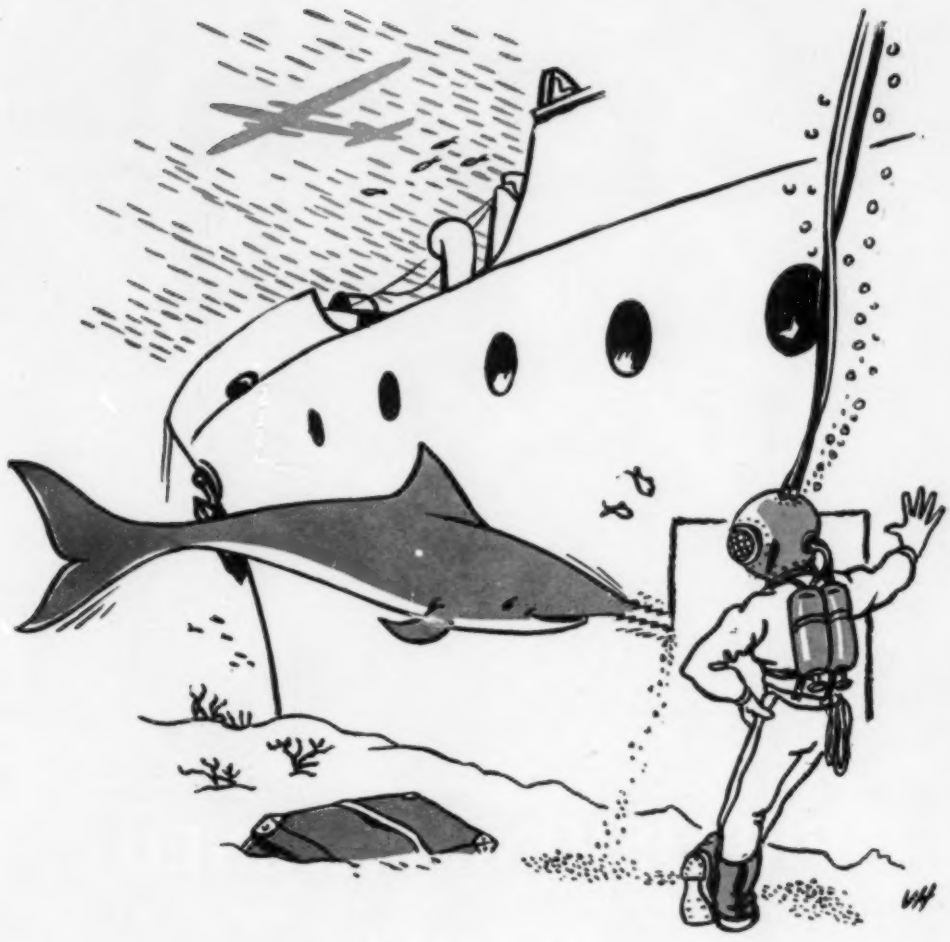

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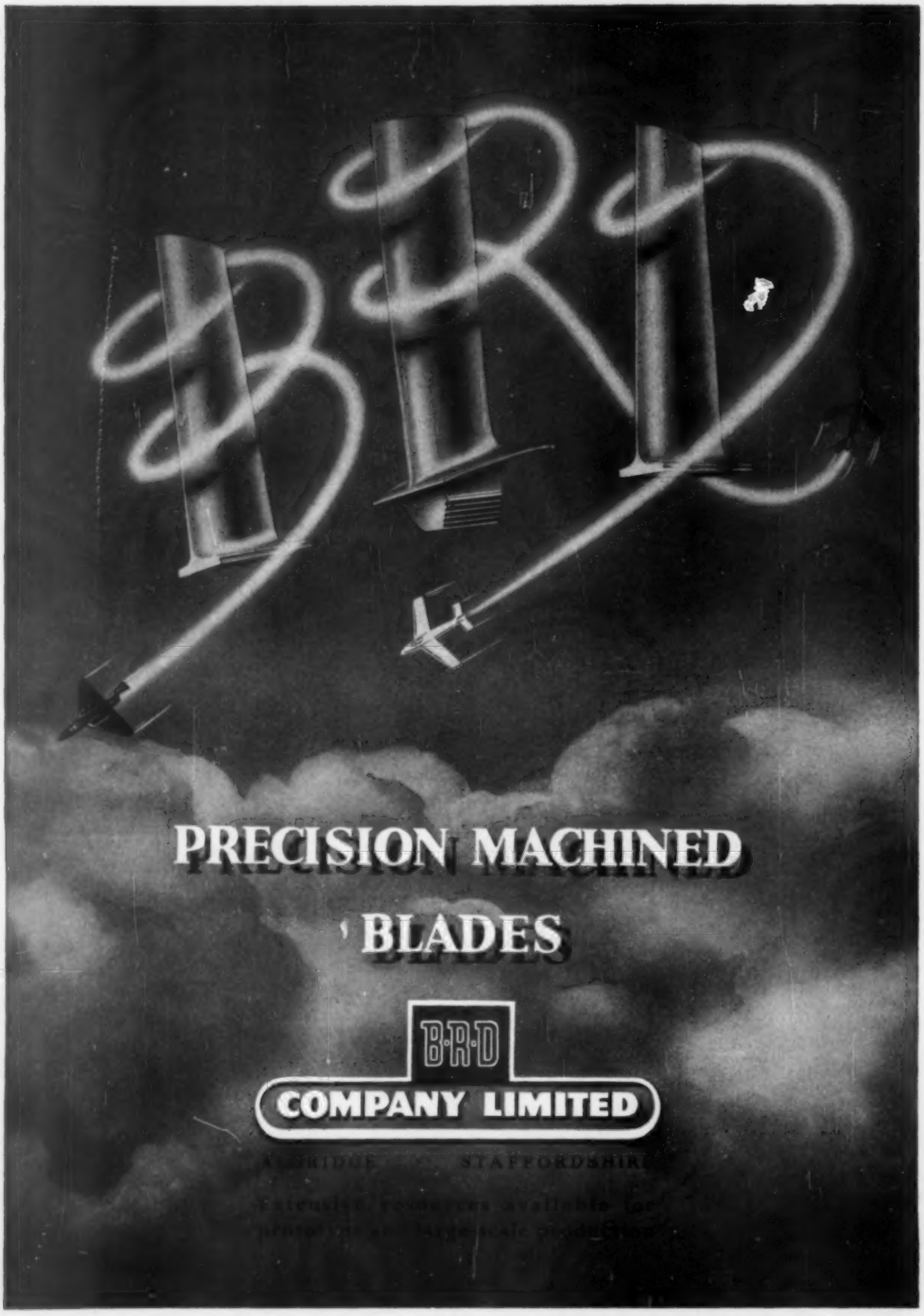
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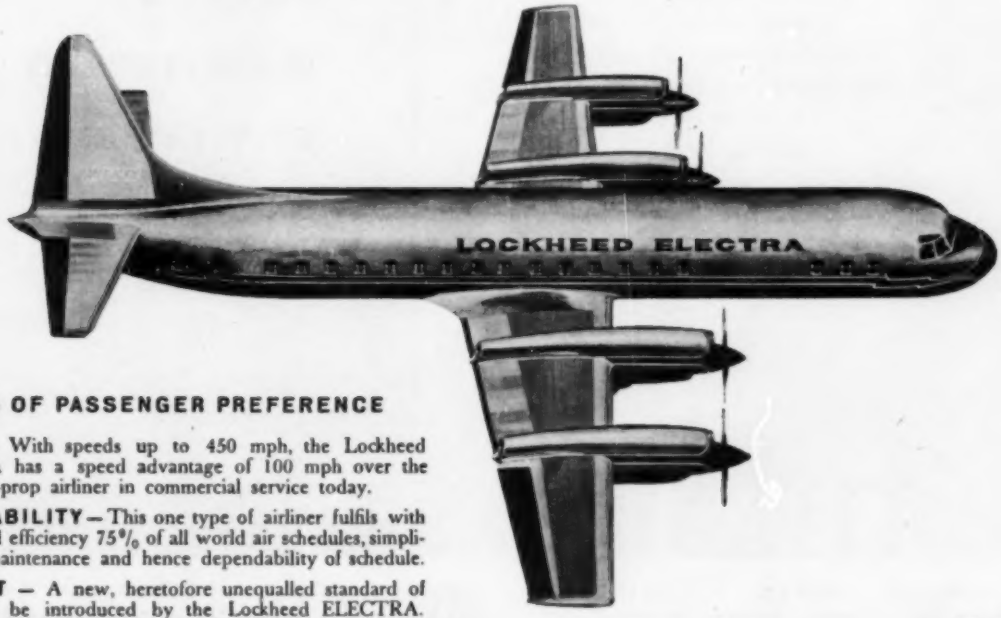

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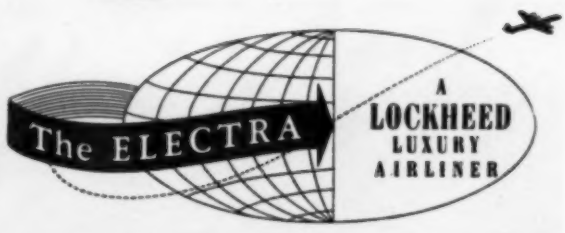

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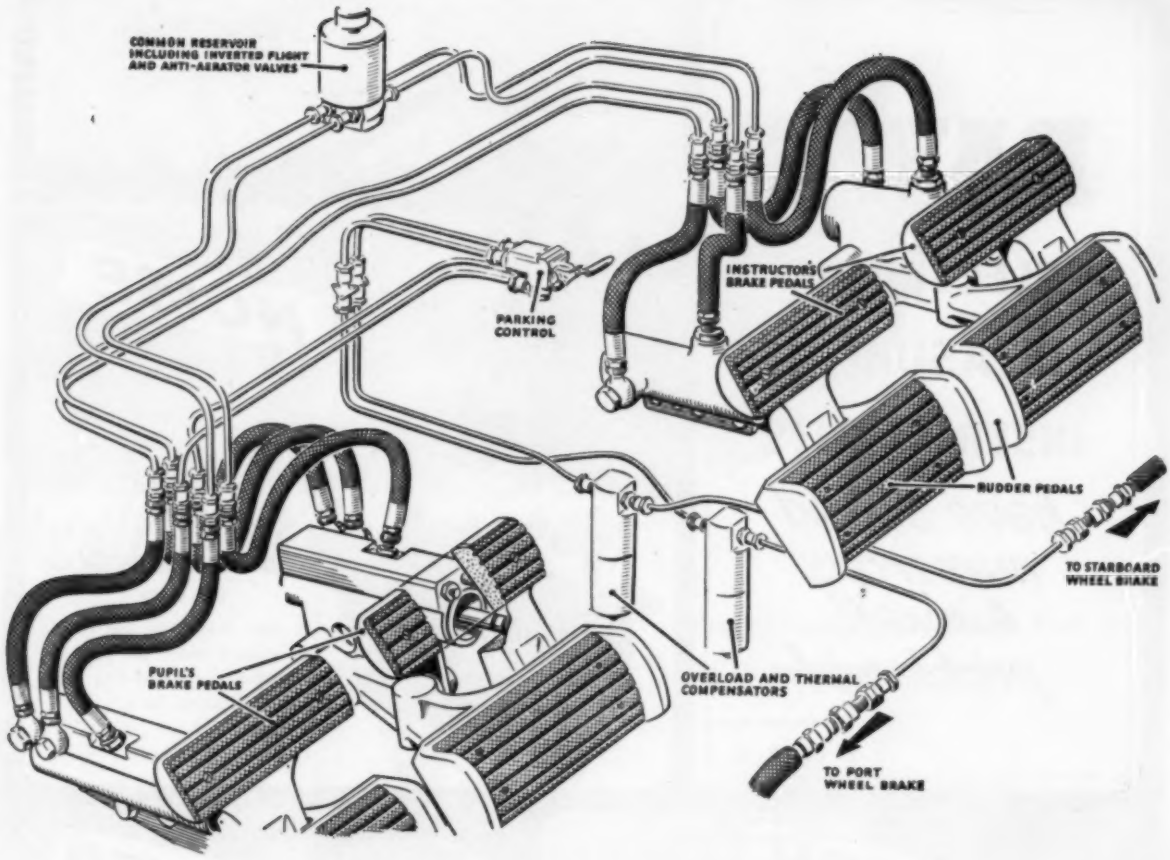

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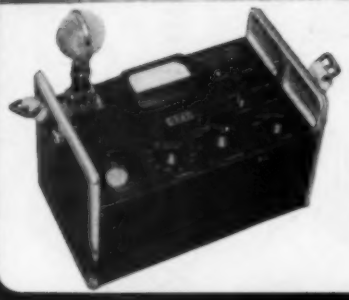

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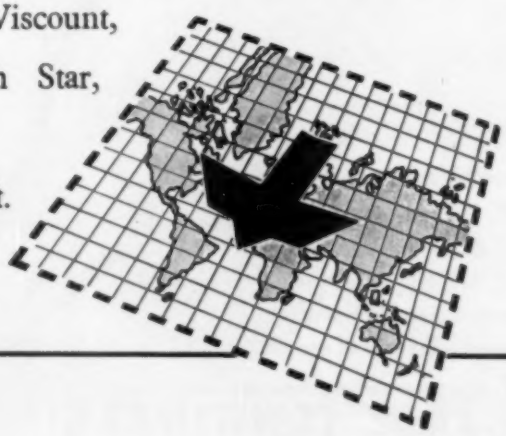

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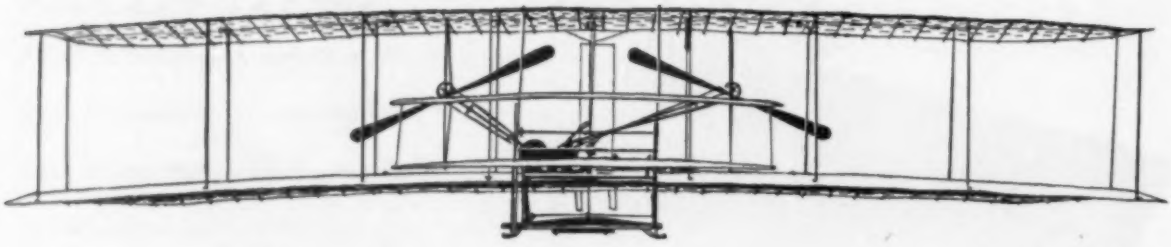
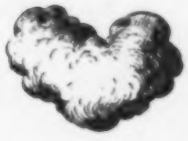


was to the Montgolfier balloon



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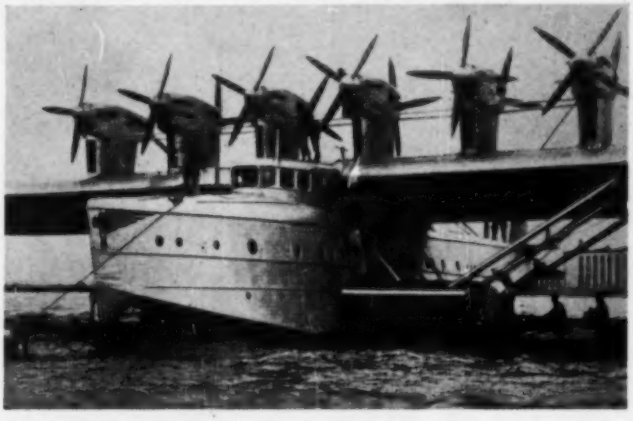

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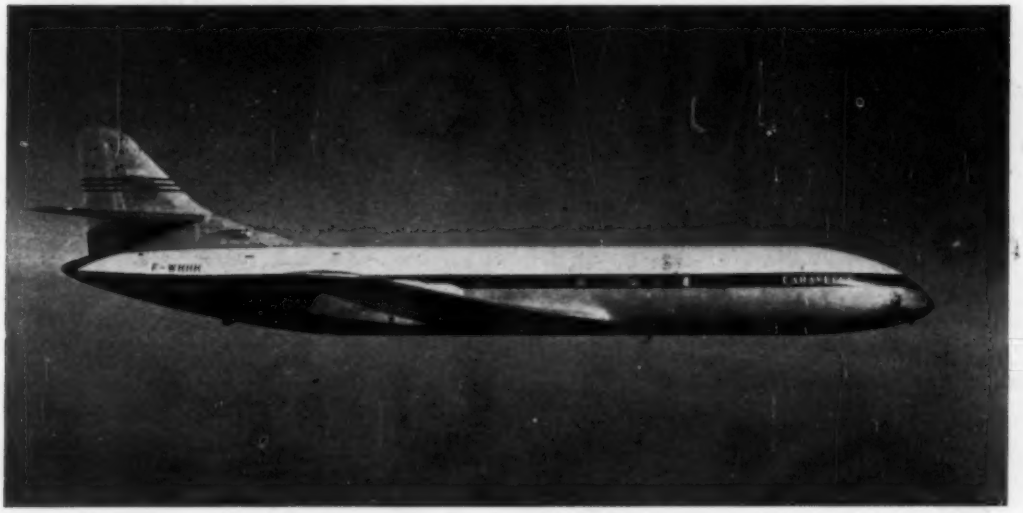

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In addition to many of the proven features of the earlier DC-6 and DC-7 series, the "Super Seven" incorporates several major engineering advances.

The increased wing span (10 feet greater than any previous Douglas plane), added to the centre wing section, raises the fuel capacity to 7,860 gallons. This means a range of 4,800 miles—550 miles more than any other aircraft in service.

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The new aircraft structure has been designed for a 140,000 pounds take-off and 109,000 pounds landing weight. In the tourist version, the DC-7C carries up to 72 passengers plus baggage, cargo and mail.

Inside the DC-7C

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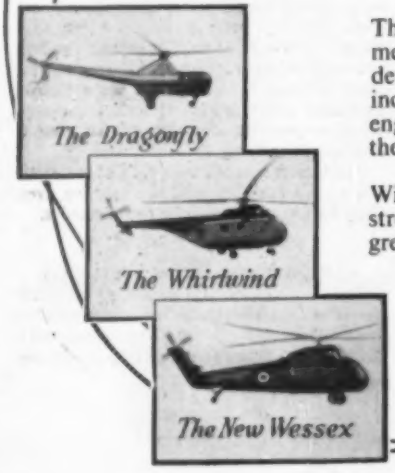

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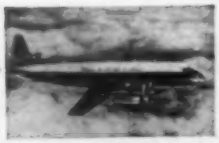
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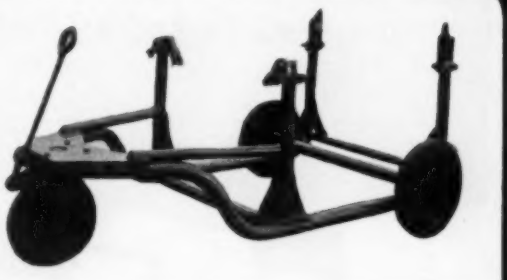

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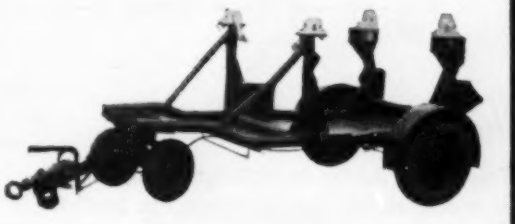

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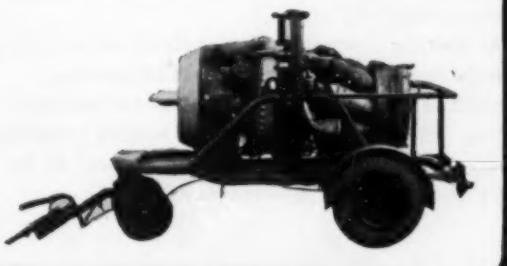

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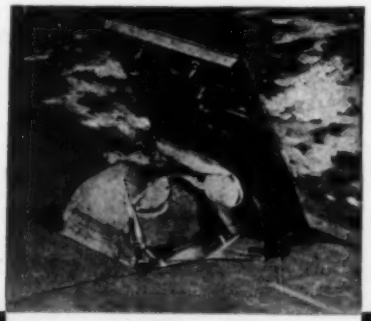

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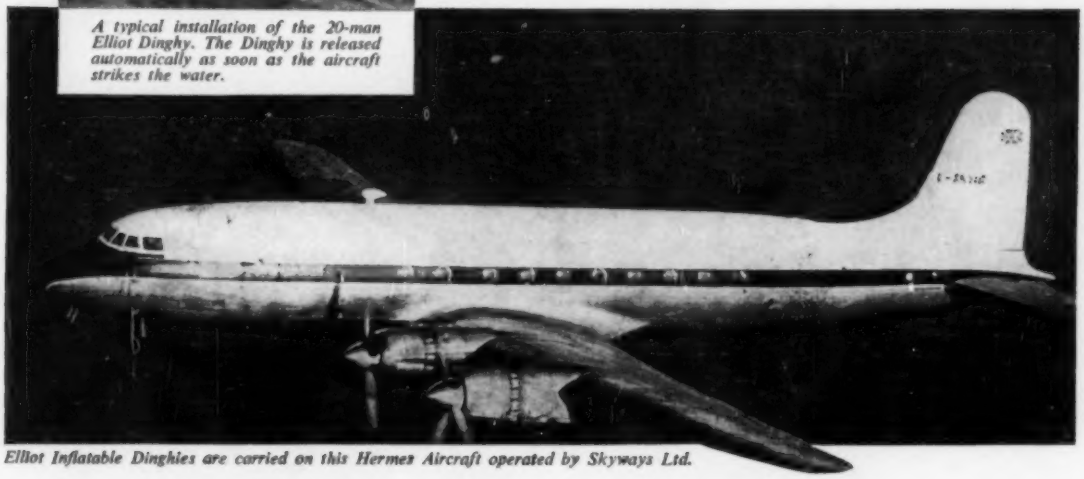

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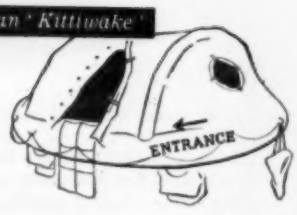
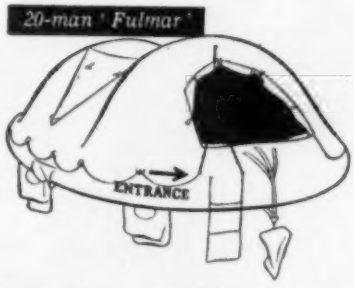


10-man 'Siskin'

20-man 'Fulmar'



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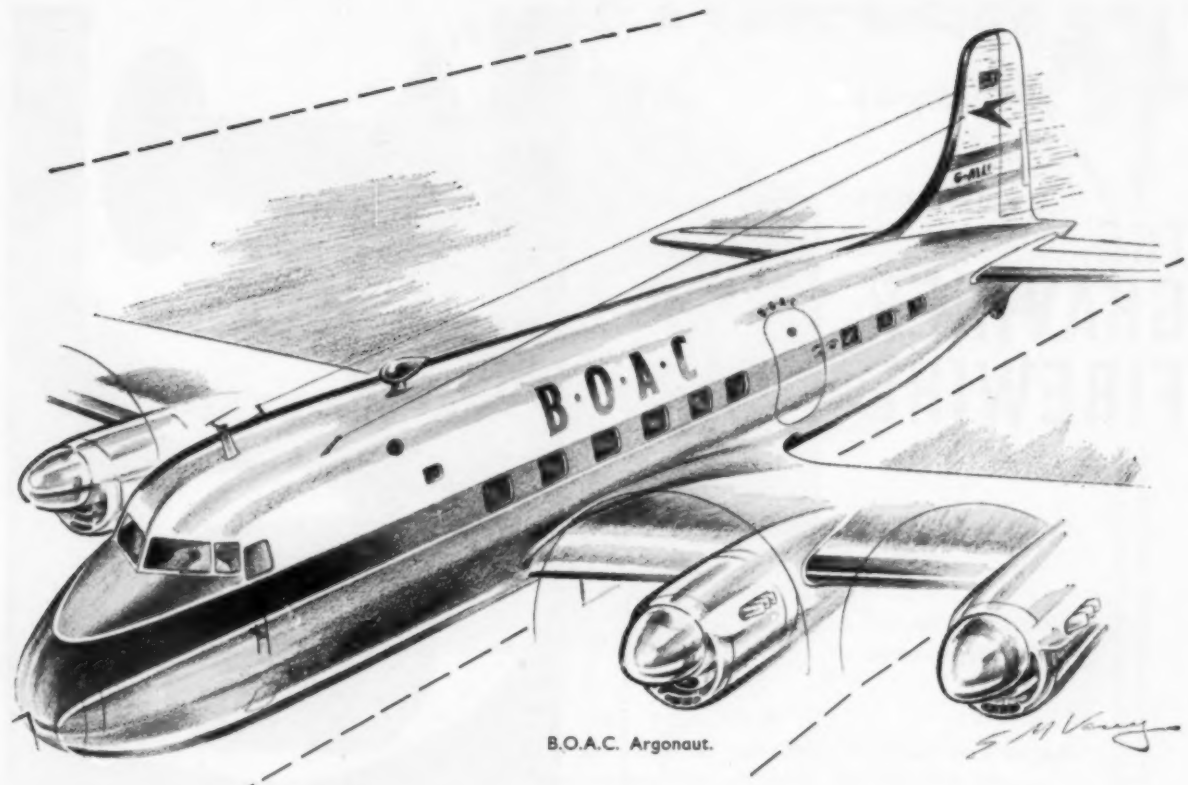

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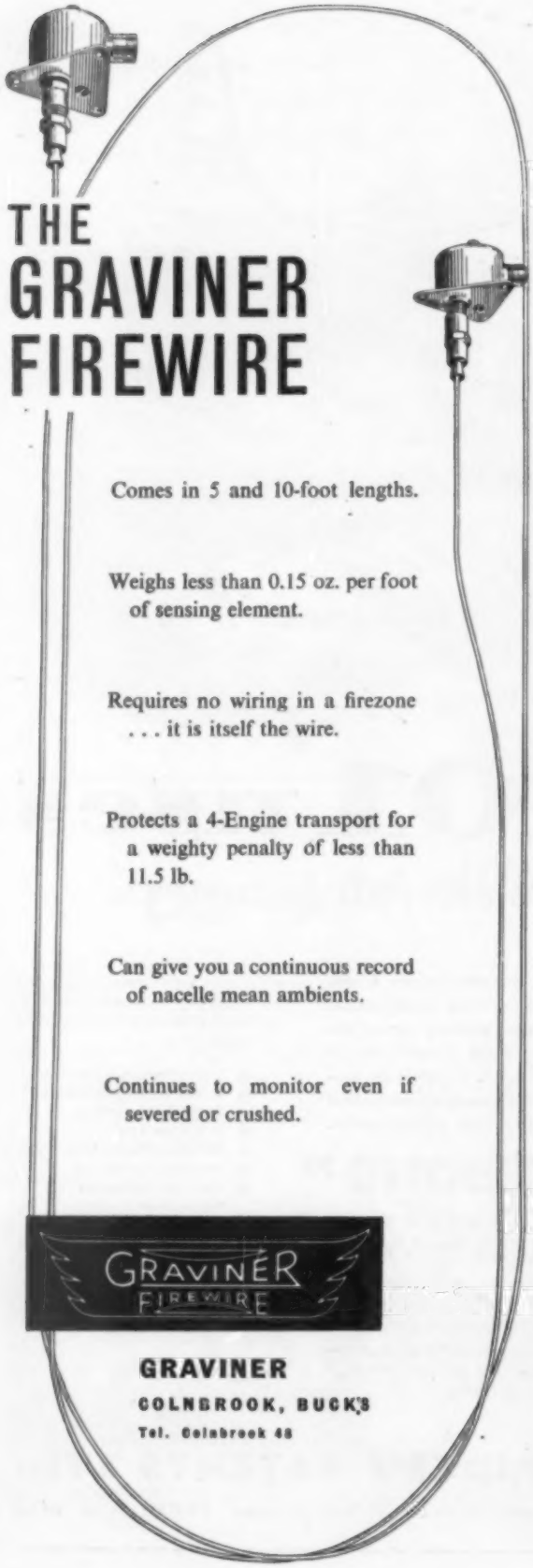

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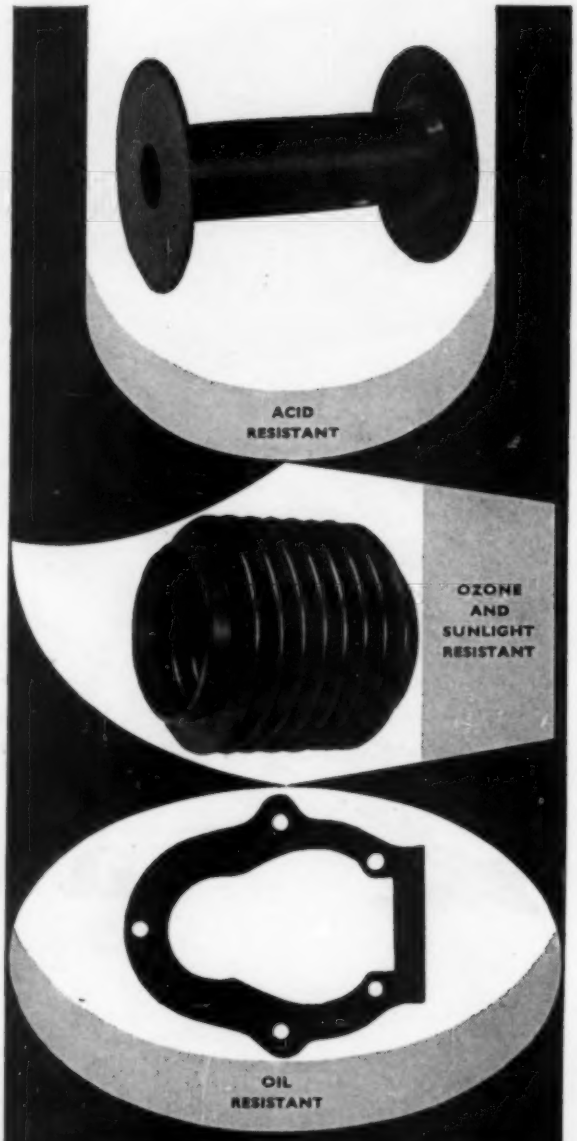

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FLIGHT and AIRCRAFT ENGINEER

No 2476 Vol 70 FRIDAY 6 JULY 1956

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5 World Gliding at St. Yan
6 Italy's Biggest Post-war Display
9 Commercial Aircraft

U-2 . . .

A NEW race of supermen appears to have risen around us. Like Abominable Snowmen these creatures have their being in the abstraction of newspaper reports and their origin and identity remain obscure. By nature they leave no tracks, but by hypothesis they have a great breadth of shoulder, for they are continually bearing up under the responsibility for acts of unauthorized disclosure, defection, betrayal and treachery. They seem to have a single Cyclopean eye, and their skin is of such thickness that they feel nothing beyond concern and alarm. They are called Top Security Chiefs, and they appear to be autonomous, since one hears nothing of Intermediate or Bottom Chiefs. (Just as nowadays nothing seems to be Confidential or Secret; if a matter is not common knowledge, then it is automatically accorded the Fleet Street grading of Top Secret.)

Judging from the international farrago involving the United States Air Force's Lockheed U-2, these secure and lofty beings are not indigenous to our islands. Regardless of the fact that any uncommon, unorthodox aircraft must inevitably excite comment and become news, somebody somewhere is evidently determined to maintain "security." The presence in the United Kingdom of one or more aircraft answering to the description of the U-2 was strongly implied in *Flight* of June 1 last, and since that date evidence has been accruing which inclines us yet more strongly to that belief. Indeed, we find ourselves so goaded by events, rumours and reports that we now propose to flaunt the T.S.C.s in an even naughtier and more deliberate fashion. This we shall do by presenting a cold collation of known facts and near-certainties.

. . . can be a Top Security Chief

The U-2 is a large high-altitude research and observation aircraft propelled by a Pratt and Whitney two-spool turbojet (in the first instance, at least, a J57). It has a straight, or slightly swept, wing of uncommonly high aspect-ratio and is incapable of supersonic speeds. Level-flight Mach number may be as low as 0.75. Possibly having originated as a Lockheed private venture, to provide information and experience for systems applicable to the F-104 supersonic fighter, the U-2 has since been supplied on a small scale to the U.S.A.F. and a few examples are to be made available to the N.A.C.A. for high-altitude research flying in Nevada. Ceiling is far in excess of 50,000ft, and it is rumoured locally that the undercarriage is left behind on take-off.

A Suffolk reader reports having observed in the Lakenheath district two aircraft answering to the description of the U-2 (one with a serial number on the tail and one without); and several of his neighbours have written corroborative accounts. Thus, as we suggested in our earlier editorial, the U-2 is no by-product of Suffolk punch. Its existence, indeed, has been officially admitted (by the N.A.C.A.), and its duties have been enunciated as the study of jet streams, turbulence and gusts, and the examination of the air for cosmic particles, ozone and radio-active content.

But although numerous members of the Suffolk yeomanry and of the local spotting brigade will recite a detailed description of the machine at the drop of a recognition book, and although (we have little doubt) some rural sportsman is even now crouching behind a hedge ready to draw a shutter on the exotic migrant bird, official photographs and technical particulars are rigorously banned by the U.S. Air Force.

We can only sit back and imagine the wildfire passage of the U-2 across the headlines and down the columns: —

"I am able to reveal (writes a correspondent) that top security chiefs are alarmed by the disclosure of top secret features of a nameless high-level plane operating from a top secret military air base somewhere in Suffolk. Behind locked doors in the Pentagon . . ."

But let us not spoil the game, for there is nothing like a hearty guffaw or a good whodunit to deflate pomposity and relieve solemnity.

FROM ALL QUARTERS

Air Economies

OVER £10 million of the £76m national expenditure cuts announced by the Chancellor of the Exchequer on June 26 affect aviation, Naval, R.A.F. and civil. A reduction of £2,980,000 in the Navy Estimates for contract work in the sphere of ship-building, repairs, maintenance and similar work is to be achieved largely by a "rephasing" of the Naval aircraft programme. There is also to be a cut of £320,000 in the R.N. air training programme.

The Air Estimates have been reduced by £8,740,000. This figure is broken down as follows: Pay, etc., of the Royal Air Force, £1,000,000; supplies, £2,050,000; aircraft and stores, £4,620,000; works and lands, £1,070,000.

The largest cut in the Estimates, that on aircraft and stores, is to be carried out by the accelerated disposal and use of stocks and the cancellation of projects. A question on the cancellation of projects was due to be asked in the House of Commons last Wednesday, July 4.

Tyne Flies

MOUNTED in the nose of an Avro Lincoln test-bed (picture last week), a Rolls-Royce Tyne flew for the first time on the evening of Thursday, June 28. The Tyne was running throughout the 100-min flight—including the take-off—and performance testing, with the outboard Merlins feathered, was started straight away. Pilot was A. J. Heyworth, Rolls-Royce chief test pilot.

S.B.A.C. Elections

AT a council meeting of the Society of British Aircraft Constructors, Ltd., held on June 27, Mr. C. F. Uwins, O.B.E., A.F.C., F.R.Ae.S., was elected president for 1956/57. Mr. A. F. Burke, O.B.E., was elected vice-president and Mr. J. J. Parkes, A.F.R.Ae.S., who was president for 1954/56, becomes deputy president. Sir Frederick Handley Page, C.B.E., was re-elected honorary treasurer.

Mr. Uwins is a director of the Bristol Aeroplane Co., Ltd., chairman of Bristol Aircraft, Ltd., director of the Bristol Aeroplane Co. (Aust.) Pty., Ltd., and was formerly chief test pilot of the Bristol Aeroplane Co., Ltd., He set up a world height record of 43,976ft in a Vickers Vespa (Bristol Pegasus) in 1932, for which he was awarded the Britannia trophy.

Mr. C. F. Uwins

Mr. Burke is managing director of the de Havilland Aircraft Co., Ltd., chairman of the de Havilland Engine Co., Ltd., and a director of de Havilland Holdings, Ltd. He is also a director of de Havilland Aircraft, Inc. (U.S.A.). He was one of the crew of the R.100 when it made its return transatlantic crossing in 1930.

The following were appointed to the S.B.A.C. management committee: Mr. H. Burroughes; Mr. H. T. Chapman, C.B.E.; Capt. E. D. Clarke, C.B.E., M.C.; Sir Roy Dobson, C.B.E., J.P.; Mr. T. Gammon, O.B.E.; Mr. W. T. Gill; Mr. H. G. Nelson; Mr. J. D. North; Mr. F. E. N. St. Barbe; Sir Frank Spencer Spriggs, K.B.E.; Sir Reginald Verdon Smith, J.P.

Representatives of associate members on the management committee are: Mr. C. E. Holmstrom (materials group), Mr. G. H. Dowty and Mr. F. Rowarth (equipment group).

Arctic Helicopters

TWO helicopters owned by Autair, Ltd., are to be used during this month and August on mineral survey work in north-east Greenland. Operating on behalf of a Danish mining company, they will be based at King Oscar Fjord, over 300 miles north of the Arctic Circle.

One of the helicopters (with rotor and tail cone removed) was "lifted" by an Air Charter, Ltd., Bristol Freighter from Southend airport to Meesters Vig in Greenland—a distance of 1,920 st. miles—early this week. This air passage makes it possible to take full advantage of the short polar summer, enabling the helicopter to be available for the whole two months in Greenland. With it were travelling Capt. Lincoln Lord, Autair chief pilot, and Mr. Tom Howie as flight engineer.

***DEVELOPMENT** of two important British aircraft is evident here. The Handley Page Victor B.1 (top) has vortex generators on its outer wing-panels, and the D.H.110 has a new, pointed, radome for improved rain-erosion resistance. The wing pylons are for fuel tanks and missiles.*

The second helicopter is being shipped to Iceland, and will be flown from there to Greenland by Capt. Greville Jacques (who wrote on Antarctic helicopter flying in *Flight* for June 15). He is to make the flight alone and with a total of 320 nautical miles to cover, including a sea crossing of 180 n.m., it will be one of the longest solo delivery flights for helicopters on record.

Russian Round-up

ADDITIONAL information is now available concerning the experiences of Western Service and civilian observers who recently returned from the Soviet Union.

The most spectacular item on the agenda was, of course, the Soviet Aviation Day, held at Moscow's Tushino Airport on June 24 (described last week). It can now be added that the new Antonov twin-turboprop military transport may also be developed as a 30-passenger airliner.

On Tuesday, June 26, Western air force delegates were conducted through the Zhukovski Air Engineering Academy in Moscow. Although visitors had only a quick walk-through they were able to inspect a mass of electronic gear including radar bombing-systems; cut-away examples of three operational jet fighters and of several new engines; 23- and 37-mm cannon; fire-control systems for fighters; low- and high-speed wind tunnels; meteorological gear; and "systems-instruction" installations. The three sectioned aircraft were a Yak-25—the twin-jet, all-weather fighter code-named Flashlight; the Mig-19, a single-seat supersonic fighter rather larger than the Mig-15 and 17 and code-named Farmer; and the Il-28 light bomber (Beagle).

Vickers-Armstrongs sent out a Viscount to bring back members of the British-industry delegation. Bad weather delayed the aircraft for one day but it arrived at Vnukovo on June 29, shortly before the Comet C.2, XK.670, left for London with the British Air Minister and other delegates on board. This Comet suffered an embarrassing failure the previous day when owing (it is reported) to corrosion in one of its six storage batteries the engines would not start. It was then due to give selected Russians a joy-ride and at the time of going to press was scheduled to honour this obligation on July 3, when it was to return to Moscow for the remainder of the British delegation. The Comet was inspected by over 300 Russians while at Vnukovo.

The arrival of the Viscount was noteworthy in that this was the first Western civil transport to visit Russia for many years. Jock Bryce flew it from London in 5 hr 50 min flying time, with a stop of 13 hr at Berlin owing to bad weather. (A point of interest is that this aircraft came through the erecting shop in 10½ weeks—quicker than any previous Viscount.) Sixty officials of the Russian Ministry of Aircraft Industries, together with designers Andrei Tupolev, Sergei Ilyushin and Artem Mikoyan, spent over an hour on board. In return British industry delegates

SHOWING THE FLAG: A Central African Airlines' Viscount, the crew of which is seen above with Mr. I. M. C. Hepburn of C.A.A., brought a British delegation home from Moscow, as described on page 2. Top to bottom, the crew are: R. Beck, engineer; D. Jones, navigator; W. R. Peasley, navigator; D. O. Glaser, co-pilot; and G. R. Bryce, captain. The Yak-12 light liaison aircraft (right) carried the banners of sixteen Soviet Union Republics at Tushino on June 24.

were entertained to a strawberries-and-cream tea aboard the Tu-104, with Andrei Tupolev acting as host. Dr. Walter Cawood, P.D.S.R. (Defence) at the Ministry of Supply and leader of the British delegation, said that a round-table discussion ensued.

On the same day the Western Service delegates visited an operational airfield and aircraft factories. Escorted by Chief Marshal of Aviation Zhigarev and his Chief of Staff, Gen. Rudenko, they visited Kubinka fighter base 50 miles from Moscow. There they were taken in open cars past a line of new aircraft, among them a twin-jet attack bomber of advanced design and capable of supersonic speeds; a heavily armed and armoured attack aircraft; and a multi-purpose aircraft powered by a single turboprop, capable of performing anti-submarine, torpedo or mine-laying rôles and described by one Western delegate as "a Christmas tree." Also on show were over 100 large aircraft including the Bison bomber which was stated to weigh 160 metric tons, and the Bear, whose range was announced as 8,000 miles. Many delegates, including Air Marshal Pike and General Twining, were much impressed by visiting an atomic power station already "on steam."

On June 30 the same officers visited the Soviet Air Force Monino Academy where hand-picked pilots, navigators and bomb-aimers of four/five years' experience are instructed in war tactics, with special emphasis on naval targets. Monino offers a three-year course and graduates 250 pupils annually; present students were away at summer camp at the time of the visit. The Western observers were shown the associated airfield, replete with Mig-17s, Il-28s and Tu-4s (B-29 copy), of which the Soviet Air Force has 1,200. Next day visits were arranged to two factories. At Engine Plant 45 the host was chief designer V. Klimov, who described developments of the Rolls-Royce Nene which this factory has manufactured since 1948. Plant 45 was described as "one of the older Russian factories still using some German and American machine tools"; 3,000 are currently employed there. The basic Russian Nenes were used in the Mig-15 and other aircraft but present production is concentrated on versions fitted with an afterburner for use in "improved Mig-17s." The party were later conducted through Aviation Assembly Plant 30 where transports (presumably Il-14s) are manufactured.

Education for Industry

THE North Gloucestershire Industrial Education Council, which exists to promote education for industry, with particular emphasis on engineering as part of the school curriculum, is holding its first "open day" on Saturday, July 14. This will be in the grounds of Arle Court, the Cheltenham H.Q. of the Dowty Group. Leading educationalists, school governors, students and the parents of promising students have been invited.

Chairman of the council is Lt-Gen. Sir John Evetts, managing director of Rotol, Ltd., and British Messier, Ltd., and his colleagues are all well-known members of major aircraft and engineering firms in the locality.

An Engineer Honoured

THE Silver Turnbuckle Award, instituted by the Society of Licensed Aircraft Engineers for presentation to individuals chosen for "the success of their careers and their overall service and contribution to the aircraft industry," was awarded for the first time last Saturday, June 30—to Mr. H. M. Woodhams.

Mr. Woodhams, who is 65, began his aviation career at Hendon and Brooklands in 1907. He obtained the first Engine Category Licence to be issued (in 1919) and holds Ground Engineer's Licence No. 2. He joined Armstrong Whitworth Aircraft in 1923 and in 1950 became managing director. An Avro-type turnbuckle was chosen as symbol for the award because it is known to all aircraft engineers.

C. of A. For the Agricola

THE Auster Agricola received its full C. of A. (No. A.4829) last Friday, and the first production aircraft—the second Agricola to be completed—will be sent out to New Zealand this month. Meanwhile, development work continues with the prototype and trials of spraying, fence-post dropping and other agricultural tasks are being carried out. The Agricola first flew in December last year and, despite the short time-lapse between first flight and certification, the C. of A. was issued one day ahead of schedule.

NEWS IN BRIEF

R.A.F. Station Halton will be the venue, next Sunday, July 8, of an important event in the model aircraft calendar—the annual gala day of the Northern Heights Model Flying Club.

* * *

The first private flight from Berlin to Moscow since the war was made last week by Mr. William Lear, a 53-year-old United States businessman, in his own twin-engined Cessna. Mr. Lear, who was accompanied by his wife, landed at the East Berlin airport *en route* to pick up a navigator assigned to him by the Russians.

* * *

The Canadian Defence Minister, Mr. Ralph Campney, announced in Ottawa recently that three new squadrons of CF-100 all-weather fighters are to be put into service, raising the number of CF-100 squadrons to 12. The R.C.A.F. auxiliary squadrons are also to be reorganized and six of them will be equipped with Canadair Sabres and T-33s.

* * *

A. M. ("Tex") Johnston, Boeing's flight test chief, has been named winner of the Institute of the Aeronautical Sciences' Octave Chanute award for 1956. This award is given annually for "a notable contribution made by a pilot to the aeronautical sciences." Johnston, who is 41 and joined Boeing as test pilot on the B-47 at Wichita in 1949, was chosen by the award committee for his excellent flight test work over a period of years.

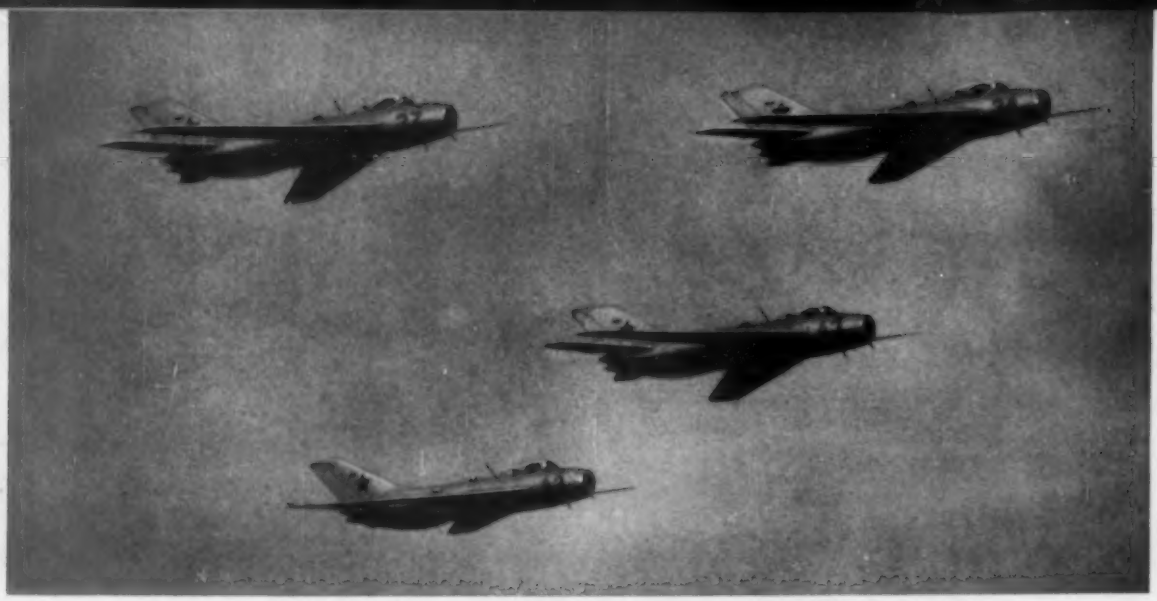
The newly named Iroquois supersonic turbojet of Orenda Engines, Ltd., a mock-up of which was illustrated in *Flight* last week, has successfully passed its 50-hr preliminary flight rating test. A strip on completion of the test was described as "excellent."

* * *

Principal officers of the Institution of Production Engineers for the coming year took office on July 1. The President is Mr. E. W. Hancock, director and general manager of Humber, Ltd., the manufacturing organization of the Rootes Group. The Chairman of the Council is Mr. H. G. Gregory, manager of the northern factories of the Fairey Aviation Company, Ltd. Both are past presidents of city sections of the Institution—Mr. Hancock of both Coventry and Wolverhampton and Mr. Gregory of Manchester.

* * *

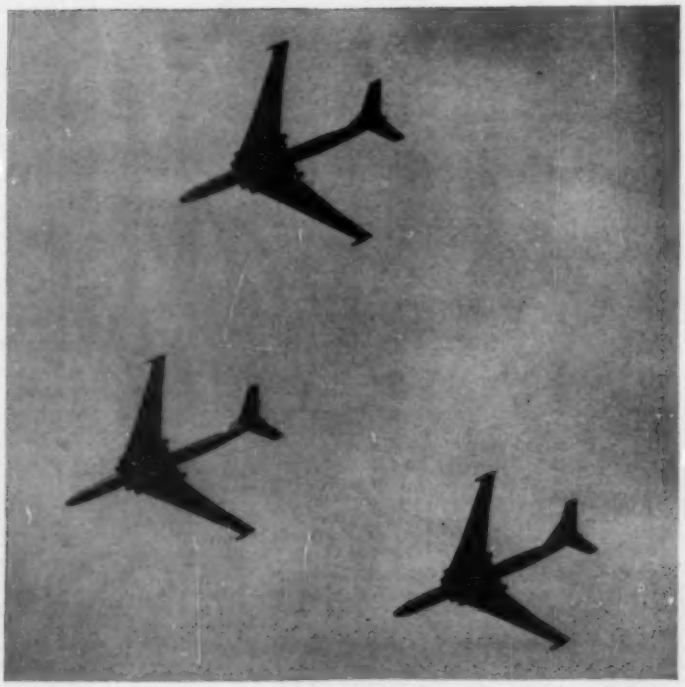
The McKee Trans-Canada trophy, presented annually for meritorious service in advancing Canadian aviation, has this year been awarded to Captain Gerald Lester MacInnis for his work on the DEW (distant early warning) radar line. The Canadian Defence Minister, Mr. R. O. Campney, announcing the award, said it went to Capt. MacInnis for his "outstanding contribution to the success of DEWline operations in the Canadian eastern Arctic." Flying a C-47 equipped with skis, without the help of navigational aids and in the depth of winter, Capt. MacInnis landed advance parties at the line sites in that region.



Revealed at Tushino

More Details of Technical Interest Disclosed at the Great Soviet Display

THE first of these dramatic photographs, secured at the Tushino display on June 24—reported in "Flight" last week—shows Farmer (Mig-19) fighters. Note the keel-like fairing (possibly di-electric), bifurcated tail-pipe, and the characteristically Russian aerials. Next is a Flashlight (Yak-25?) all-weather fighter with new, pointed, radar nose; then a heavily swept fighter-research aircraft, with a fuselage and tail resembling those of the Sukhoi delta illustrated last week; and last, three Bisons.



Heralds *would improve the picture*

in Kandahar

These Afghan growers bring their fruit to a big market—millions of pounds' worth is sold abroad yearly. This means a great deal in a land where modern industry is not advanced.

From Kandahar comes fresh fruit in varied profusion. Mulberries, pomegranates and quince grow and ripen in valley orchards and gardens alongside cherries, figs, apricots and peaches.

Carefully packed in baskets, this fruit may come to market over stony tracks, a donkey's burden. Pack animals are indispensable in a country of forbidding terrain where means of transport are limited.

Yet speed is important when such perishable goods are on the move.

Cheap and plentiful air transport could alter the whole position; it could serve both the agricultural communities and the industries that are to come. For the fruit growers, for example, it could mean a bigger market in other provinces and abroad.

Heralds, using small, simply equipped airstrips, could do the work here better than any other aircraft.

for 9 *good reasons*

- **Safety: four-engined assurance with full load.**
- **Reliability: strongly and simply built for long life and easy maintenance.**
- **Performance: meets world-wide flight requirements with a clear margin in hand.**
- **Versatility: passengers, freight or a mixed load up to 10,500 lb.**
- **Economy: costs 1½d. a passenger-mile and 1/3½ a ton-mile to run.**
- **Small airfields: can take-off with full payload from 1,000-yard grass landing-strips up to 5,000 feet.**
- **Cruising speed: 200 m.p.h.**
- **Pressurisation: efficient and comfortable travel up to 20,000 ft.**
- **High wing: easy loading and a good view for passengers.**

HANDLEY PAGE RADLETT · LONDON · READING

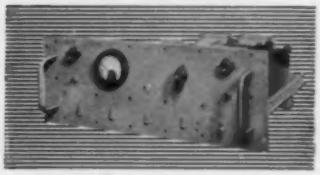
Marconi

VHF COMMUNICATION SYSTEM FOR AIR TRAFFIC CONTROL

...AT YOUR FINGER TIPS

The corner of an Air Traffic Controller's desk showing the neat grouping of VHF channel controls.

Top right is the 50-watt Type AD801 Transmitter housed in a cabinet with its associated Modulator and Power Supply.



The Type AD818 Crystal controlled Receiver shown in the bottom illustration is used in conjunction with both the 801 and 811 Transmitters.

THE AD801/811/818 COMBINATION WITH ITS ASSOCIATED CONTROL EQUIPMENT FEATURES:—

- Flexibility in choice of initial installation
- Remote operation by up to 5 air traffic controllers
- Operation on up to 10 channels by any one controller
- Facility in adding further channels to meet increased traffic
- Full tropicalisation and robust construction. Built to meet M.O.S. spec. K114/E
- Suitability for mobile application

Lifeline of Communication

MARCONI

Airport and Aircraft Radio Systems

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX

LA 29

The contestants' park, wherein grace and beauty (as always on these occasions) abounded.

World Gliding at St. Yan

from Kenneth Owen

"AT the heart of France," the Vichy Tourist Bureau's leaflet began, "among the fertile regions of Burgundy and Beaujolais and the rich countryside surrounding Charolles and Nevers, between the Mont de Morvan, the Massif Central and the plains of the Loire and the Allier" —with here a pause for dramatic effect— "lies a great open tract of land: SAINT-YAN." Which, as readers of *Flight* should be already aware, is where the 1956 World Gliding Championships are being held.

The championships were officially opened on June 29 by M. Roger Duveau, Secrétaire d'Etat à la Marine, after the teams had been presented, their national anthems played and their respective flags unfurled. As the total number of countries represented is 27, this ceremony took some time. It had been preceded by a stimulating display of solo and formation aerobatics by the four Stampes of St. Yan's own aerobatic team.

On the first morning, I was able to sample the thermals of the St. Yan area—and also to check the Vichy Tourist Bureau's knowledge of geography—during a flight of over an hour in the Slingsby T.42, the British two-seater entry, with Frank Foster in the front seat. Conditions were similar to those of the latter part of the practice-flying week, with good convection but requiring a fair amount of work to find the lift and stay in it. As we circled over Paray-le-Monial, we were joined by one of the French Bréguet 901s and a non-competing Fauvel AV. 36.

The British team at St. Yan consists of Mrs. Ann Welch (team captain); Philip Wills and Geoffrey Stephenson, each flying a Slingsby Skylark 3 in the single-seater class; and H. C. N. "Nick" Goodhart and Frank Foster with the second prototype T.42 in the two-seater class. During the practice week, Wills established a British national single-seat record for speed over a 200 km triangular course; and British national two-seater records for speed over a 100 km triangle and for out-and-return distance (141 miles) were set up by Goodhart and Foster.

Although the British team is all-Slingsby equipped in this year's contests, Elliotts' Olympia is being flown by Bill Ivans, Jr., of the United States. A total of five Skylark 3s is included in the single-seater entry list, and among the two-seaters is the French Bréguet 904, which made its first flight only one month ago.

In the first competition, for a flight inside France, on June 30, the longest distance was achieved by José Cuadrado of the Argentine. He flew 267 miles to Mauberge in his Skylark 3. Paul MacCready, of the U.S., came second with 242 miles in his Bréguet 901 and several other pilots exceeded 230 miles. All the gliders were released from aircraft at 2,000ft.

Monday's event, a race to St. Etienne—62 miles south—started late owing to unfavourable weather. Many pilots, including Philip Wills, who climbed to 22,000ft, took advantage of an afternoon thunderstorm to gain height. "Nick" Goodhart and Frank Foster were first to reach the objective.

Further details of the competing sailplanes, together with an account of the first week's flying, will be included in next week's report from St. Yan.

(Left) Living quarters for the contestants from 27 nations.

(Lower left) Some of the 20 Stampe tugs provided by the French School of Aerobatics for which St. Yan is famed.

(Below) The British team.

Italy's Biggest Post-war Display

Inauguration of Rome's New Airport

AS briefly recorded in our pages last week, the inauguration of Rome's new airport at Fiumicino on June 24 was marked by a major air display organized by the Italian Ministry of Defence. Attended by the Minister of Defence, Sig. Taviani, and the Chief and Assistant Chief of the Italian Air Staff, Generals Raffaelli and Remondino, and by many other distinguished personalities, the function was the most ambitious of its kind held in Italy since pre-war days.

The theme of the air show was the progress of aviation since the earliest days and the sequence of training undergone by the modern jet-fighter pilots. First off in the historical cavalcade was a Farman biplane dating from 1910. It was followed in a straight flight down the runway by a Fiat C.R.32 biplane fighter of the 1930s. An example of Fiat's latest work, the F-86K, then made a high-speed pass and departed skywards in a long series of upward rolls. Two F-84Fs produced sonic booms and flew past "on the deck"; then, as they in turn disappeared in a flurry of upward rolls, the Fiat G.82 Nene-engined trainer and the Aerfer Sagittario passed over. The latter machine had made its first flight only a few days before.

From technical progress the emphasis passed to methods of training; a Macchi 416 (Italian-built Fokker Instructor), a T-6 Harvard and a Fiat G.59 flew past, the last-named making a series of rolls at very low level. From the Italian air university at Amendola a T-33 arrived to roll its way along the whole length of the runway, to zoom in a series of upward rolls and, winging over, to dive back at the field with a series of downward rolls. Hardly had this aircraft departed than a formation of 23 Macchi 416s flew over, forming the letters S.A., standing for Scuola Alghero training base. The Scuola Elmas followed with a formation of 19 T-6s arranged in an S and an E. A further 16 T-6s announced the S.L. of the Scuola Lecce, and 20 Fiat G.59s flew past in close formation. Finally eight T-33s displayed the A of the Amendola training academy. The traditional pupil-and-instructor act was demonstrated by two T-6s, the instructional "patter" being relayed to the crowd over the loud-speaker system.

A brief interlude was devoted to Italian civil flying which, despite constant support from the Ministry, has d[illegible] in Italy. A Piaggio P.149 of the type just chosen as a [illegible] for the German Air Force was expertly demonstrated and its safety and manœuvrability were well shown off. The final training item was a display of aerobatics by the Fiat G.82, which demonstrated the standard of flying required before a military pilot can be admitted to the Italian fighter wings. The commentator did not fail to point out that the manœuvres executed at very low altitude

The members of the English, American, French, Italian and Spanish aerobatic teams (in that order across and down the page) which performed at Fiumicino on June 24. They flew respectively Hunter 4s, T-33s, Mystère IVs, F-84Gs and F-86Es. The first three teams are already well known; the Italians have performed outside their own country and the Spaniards were appearing abroad for the first time.

Actually flown in the historical part of the display were the inter-war Fiat C.R.32 single-seat fighter and the Farman biplane of 1910 vintage. The latter's pilot, in appropriate flying kit, is seen fraternising with the Italian pilot of an F-84F.

by the G.82 were normally done much higher up by pupil pilots. The Fiat pilot carried out a complete sequence of classic aerobatic evolutions and finished with an engine-off stall and spins.

While the first of the aerobatic teams, the four Belgian Air Force Meteors, took off and prepared for their display, three Italian Canguro gliders from the military gliding school, run by the famous Colonel Adriano Mantelli, gave an aerobatic demonstration and landed in front of the president's tribune. After the four Mystères of the Patrouille de France had taken off, the Belgian Meteors, flown by Maj. Bladt, Capt. Ongena, Capt. Dewulf and Lt. de Prins, gave a fine formation aerobatic show, in which the station-keeping of the number four, "in the box," was particularly praiseworthy. He held his position as if glued under the tail of his leader. No sooner had the Meteors departed than No. 43 Squadron's team of Hunters took off to stand by while the French Mystères gave their show. The French pilots, Lt. Beteille, Sgt. Chefson, and Sgt. Gattegno, were led as usual by Lt. Tourniaire. They went through the sequence of manœuvres for which they have justly gained their fine reputation and concluded with the classic bomb burst, streaming green smoke the while.

The Mystères having landed, the Fighting Cocks of No. 43 Sqn. took over, F/L. P. Bairsto leading F/O. R. Smith, F/O. S. Wild and Sgt. Plt. T. Lampitt. The precision and variety of their show impressed both the spectators and the members of the other formation teams. Their perfect technique was greatly admired and they concluded with an upward bomb burst, streaming smoke. Their final effort was particularly impressive; they landed in pairs from opposite ends of the runway, passing each other at the half-way point directly in front of the grandstand.

The emphasis of the show now changed to a demonstration of the use of aircraft in war. First came a World War 1 type of dog-fight, complete with machine-gun noise, between two T-6s which never went higher than 500ft. It ended with the simulated destruction of one of them. Immediately afterwards two "enemy" Mustangs attacked the centre of the airfield with machine guns, only to be immediately intercepted and driven off by two F-84Gs under G.C.I. control. Close behind them came six three-engined Savoia-Marchetti S.M.82s simulating enemy bombers, and these in their turn were intercepted by four F-86Ks. The Navy then took a hand with a low-level flypast by a P2V Neptune, a SB2C-5 Helldiver, a Cant Z.506 three-engined ambulance aircraft and the Piaggio P.136 air/sea rescue amphibian.

Seven Italian Air Force Agusta-Bell 47 helicopters then presented a dainty aerial ballet which ended when each aircraft in turn performed a deep obeisance before the president. Take-off and landing aid demonstrations included two F-84Fs taking off, one with and the other without R.A.T.O. boost. As they cleared the field two F-86Ks landed, one of them stopping very short with the aid of its tail-braking parachute.

The show now became really warlike. In the face of heavy anti-aircraft fire, four F-84Gs assaulted with napalm a target a kilometre away from the grandstand, starting a considerable fire. Four more F-84Gs backed up with bombs and rockets, and yet another four stoked up with more napalm. As the anti-aircraft fire diminished in intensity under this onslaught, a final attack with bombs and machine-gun fire was pressed home. The target now being considered "pretty well jellied up", nine C-119 Packets came in low to drop 240 parachutists complete with heavy equipment and vehicles. The target was not unnaturally soon overrun, and helicopters went in to pick up the "wounded."

Having thus made its point forcefully, the Italian Air Force then presented a parade of strength in the form of twelve Vampires from the 2nd Fighter Wing, a unit which became famous during World War I and includes among its past members such aces as Francesco Baracca, Arturo Ferrarin and Mario de Bernardi, Schneider Cup winner and still a well-known figure in Italian aviation. The 2nd Wing, now commanded by Colonel Lucertini, is converting on to F-86Es. The 12 Vampires were followed by 12 F-86Es of the 51st Group, eight RF-84Fs of the 3rd Group, 12 F-86Ks of the 4th Wing, 16 F-84Fs of the 6th Group and six F-84Gs of the 5th Group.

After this air parade there were more formation aerobatics, this time by four Spanish Air Force F-86Es, the four T-33s of the U.S.A.F.E.'s Acrojets team and by four Italian Air Force F-84Gs. The Spaniards performed first, with courage and skill, the pilots being Lt. Col. G. Hevia Alvarez Quinones (leader), Capt. B. Garcia Lopez Rengel, Lt. J. Alvarez de la Vega and Lt. H. Maura Pieres. The Acrojets followed with their usual high-precision flying, beginning with a Cuban eight and ending with a fine bomb-burst at low altitude, streaming smoke. The official display was brought to a close by the Italian aerobatic team led by Capt. Di Lollo with Lt. Pisano, 2nd Lt. Vezzi and Sgt. Maj. Rossini. They performed a series of classic manœuvres with formation changes in perfect style and precision. Ending with a bomb-burst, streaming smoke, they came back for a finely judged, low-level cross-over.

At this juncture the crowd of 200,000 spectators asked for a repetition of the sonic boom which had that afternoon been demonstrated in public for the first time in Italy. So Capt. Ceoletta brought his F-84F back to arrive only two seconds after a splendid bang and disappear again skywards in a long series of very fast upward rolls. The spectators then went on their way greatly rejoicing, their 10,000-odd cars, heading for Rome, controlled by helicopters in radio contact with the highway police.

The show over, the Mario De Bernadi Aeroscooter, a new ultra-light which will eventually be fitted with an Autogiro-type rotor, took off for home. A sizeable static show had meanwhile been available; it included models of many old and new aircraft including the little Caproni F.5, Italy's first small jet aircraft, and the M.C.72 which won the Agello speed prize in 1934 at 437 m.p.h.

FORTHCOMING EVENTS

June 29-
July 13. World Gliding Championships, St. Yan, France.
July 7-9. Royal Aero Club: Private Rally, Deauville.
July 8. Northern Heights Model Flying Club: Gala, Halton.
July 14-15. Aero Clubs of Trento and Bolzano: Eighth International Tour of the Dolomites.
July 14-15. Dusseldorf Aero Club: Air Rally.
July 14-25. International Gliding Competition, for the Coupe Jacques Coeur, Bourges.
July 15. Royal Belgian Aero Club: International Gliding Competition, Namur.
July 15. R.Ae.S.: Garden Party, Wisley.
July 18-22. Venice Aero Club: International Aeronautical Exhibition.
July 21. R.Ae.C.: National Air Races, Third Round (including King's Cup Race), Baginton, Coventry.
July 21. R.N.A.S. Lossiemouth: At Home.
July 21. R.N.A.S. Anthorn: At Home.
July 22. Northamptonshire Aero Club: At Home.
July 22. Yorkshire Aeroplane Club: At Home.
July 28. R.N.A.S. Yeovilton: At Home.
July 28. R.N.A.S. Culdrose: At Home.
July 28. Helicopter Association: Rally and Garden Party, Ripley.
July 28-30. Livorno Aero Club: Air Rally.
Aug. 4. R.N. Air Station Brawdy: At Home.
Aug. 5-6. World Power Model Championships, Cranfield.
Aug. 11. R.N. Air Station Lee-on-Solent: At Home.
Sept. 3-9. S.B.A.C. Display, Farnborough ("Public" days, 7th, 8th, 9th).

CIVIL AVIATION

NORTH SCOTTISH DECCA CHAIN

VISCOUNT *Sir John Franklin* was undoubtedly the right vehicle in which to journey to Aberdeen last Tuesday week for the opening of the North Scottish Decca Navigator Chain. Like all other B.E.A. machines of her class she is fully Decca-equipped, and for the Scottish trip her skipper was Capt. E. R. Wright, a senior pilot of B.E.A.'s Viscount Flight and author of the paper *Pilot and Flight Log*, delivered at a recent Institute of Navigation symposium and printed in *Flight* of May 18 last.

The Viscount was on charter to Decca, and passengers included Mr. J. Henderson Stewart, M.P., Joint Parliamentary Under-Secretary of State for Scotland, and Lady Tweedsmuir, M.P. for Aberdeen South. British and foreign Services and the ever-multiplying Decca-user companies and departments were represented by senior officials.

The Decca Navigator North Scottish chain, now complementary to the North British chain, English chain, and South-West British chain. In West Europe are the Swedish, Danish, German, French and South-French chains.

At Aberdeen's Northern Hotel the new chain was declared open by Mr. Henderson Stewart, whose remarks had a mainly nautical flavour (understandably, having regard to Aberdeen's eminent position in fishing and shipping). By touching a switch he was able "to add the last link to a chain of land stations that plot in fair weather and foul the positions of a thousand vessels round our shores." The boon it would bring, he said, could scarcely be exaggerated. No one who had been to sea in the *Queen Mary* and a herring drifter—and he had been in both—could ever forget the tense, groping, cumulative anxiety when fog enveloped the course. On behalf of the Secretary of State for Scotland, he paid his tribute of gratitude and respect to the skill, foresight and drive of the Decca Navigator Company.

Following addresses by Mr. E. R. Lewis, chairman of the Decca Navigator Co., Ltd., and Mr. H. F. Schwarz, managing director, Mr. D. C. Clark, of the Ministry of Transport and Civil Aviation, announced that as he spoke a signal was being sent to all ships notifying them that the chain was fully operational and had been approved by his Ministry.

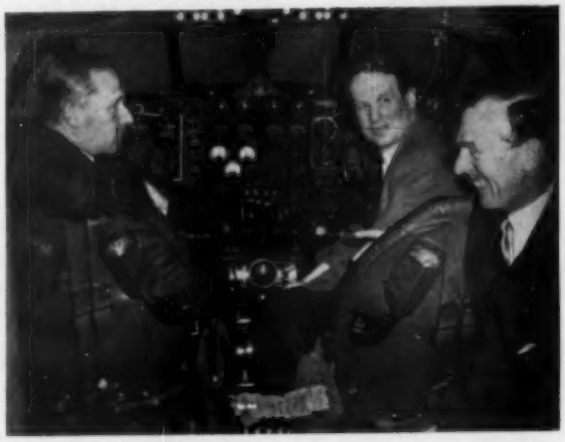
The four stations of the chain—at Peterhead, Lerwick, Butt of Lewis and Kirkwall—now complete the coverage of the British Isles by the Decca system, and coverage is thereby extended well beyond the Faroes to the north, to Scandinavia in the east, and well out into the Atlantic to the west. Not only liners and fishing vessels but ships of the Royal Navy, the D.H. Heron air ambulances of B.E.A. and other locally operated aircraft will benefit from the new coverage.

A point of interest to Scottish observers is the re-siting of the transmitting stations of the North British chain, one of which will be located near Stirling. This development is part of the Dectra (long-range navigation) trials programme across the North Atlantic, to be conducted in collaboration with the Ministry of Supply.

A NEW LOW

THE Viscount 700 has been cleared by A.R.B. for fully automatic approaches down to within 200ft over the runway when fitted with the Smiths S.E.P.2 autopilot. No change in minima is required when the approach is made in turbulent conditions, and the Board's approval is qualified only by its insistence that the installation is to the approved standard.

This break-off height limit is claimed to be the lowest to be approved by any civil authority in the world, and was achieved after a considerable period of flight-testing, some of it with g-recorders to examine the loadings imposed by the action of the automatic pilot.



Mr. Harold Watkinson (left), Minister of Transport and Civil Aviation, seen in the cockpit of the D.H. Comet 3 a few moments after landing from his 50-min flight at Hatfield on June 29. With him are chief test pilot John Cunningham and (right) Mr. A. F. Burke, managing director of the de Havilland Aircraft Company.

BREVITIES

A B.O.A.C. technical mission led by Mr. A. C. Campbell Orde, the operations development director, left for the U.S.A. on July 1 to assess the DC-8 and Boeing 707 jet airliners. Mr. Gerard d'Erlanger, B.O.A.C.'s chairman, is also expected to visit America.

* * *

The opening of the new civil airport at Salisbury, Southern Rhodesia, on July 1 was marked by an announcement that B.O.A.C. will use Salisbury rather than Livingstone on their London-Johannesburg service. Seven international airlines use the airport, and a further seven are considering it as a stopping place on their South African routes.

* * *

Bristol Aero Engines (Western), Ltd., a subsidiary of the Bristol Aeroplane Co. of Canada, are extending their plant at Vancouver International Airport by almost 50 per cent in order to provide overhaul facilities for the Proteus engines of C.P.A. Britannias.

* * *

According to Prague radio Czechoslovak Airlines have made preliminary purchasing inquiries for the Tu-104 passenger transport, to be used on their long-range international routes.

* * *

A cocktail party was given on June 29 by the tenants of Bristol Airport—notably Aer Lingus and the Bristol and Wessex Aeroplane Club—prior to its return to the municipal authorities. One of the first to receive a licence (on May 8, 1930), Bristol Airport has been requisitioned since 1939.

* * *

The 128 passengers and crews of a United Air Lines DC-7 and a T.W.A. Super Constellation lost their lives on June 30 in the worst disaster in civil aviation history. The two aircraft, which left Los Angeles within three minutes of one another, crashed in the Grand Canyon, Arizona. If—as seems certain—collision occurred, the accident emphasizes the worst fears of the U.S. civil aviation authorities, whose most serious concern is for the country's congested airways. (Last year an average of ten near misses occurred every day.)

* * *

Two more local service airlines have ordered Fairchild-built Friendships. They are Piedmont Airlines, who have signed for 12 plus an option on 12, and Bonanza Airlines, who have ordered three with an option on three more. (The other airlines are West Coast, 4; Mackey, 6; Frontier, 2.)

* * *

In Hamburg, from June 12 to 15, there was held the fifth annual general meeting of the International Aircraft Brokers Association. It was reported to the delegates of twelve countries that general relaxation of the formalities required of independent operators should help to develop air chartering. Following shipping tradition, production of Standard Charter Parties is receiving the co-operation of lawyers in seven countries to bring documentary proposals in line with international law. The next A.G.M. of I.A.B.A. will be held in London during September 1957.

No other Anti-submarine Aircraft

is so compact, efficient and economical as the Gannet.
It combines in a single aircraft the ability to search and strike with the most formidable modern weapons, has twin engine reliability and is equally suitable for ship or shore based operations. Gannets are in squadron service NOW with the Royal Navy and Royal Australian Navy.

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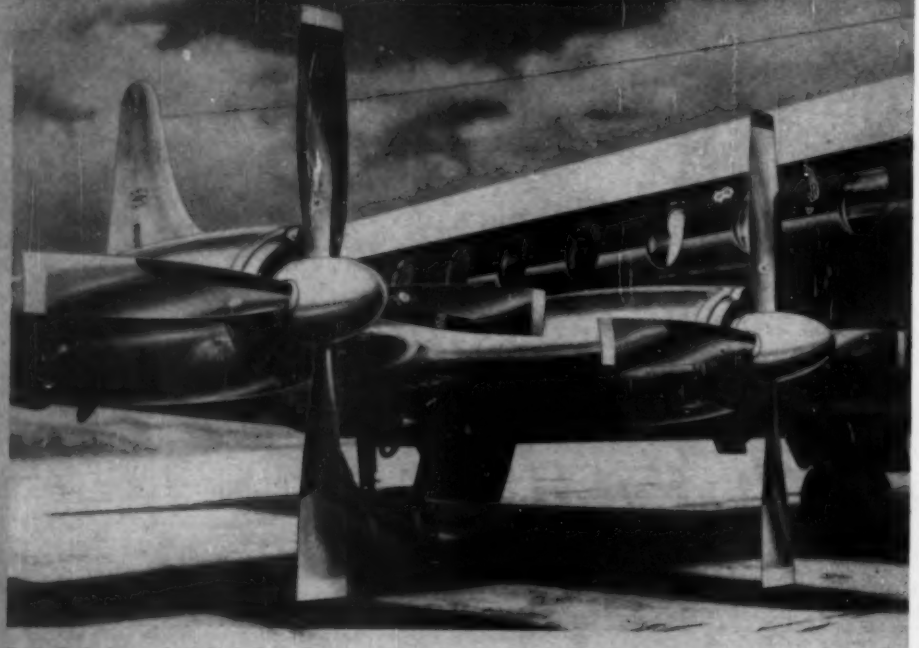

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COMMERCIAL AIRCRAFT

Airliners of the World

A "FLIGHT" COMPILATION

AIR commerce is above all a business of aeroplanes. This truism, we feel, is excused by recent unwarranted and unhealthy preoccupation with airline personalities and finances rather than with equipment; and it is one which the coming years will surely corroborate.

In this realization our present review has been prepared. It aims at impartiality as between nations and companies, and it appears as a new era of transport opens. Rivalry and romance in that era will have no less a place, and enterprise no less a reward, than in the age of sail.

In our reference to impartiality we had especially in mind the method and extent of treatment, and no significance should be attached to order of precedence. We had hoped to deal with the various aircraft in a descending order of weight, but purely mechanical considerations intervened. An earnest of our unbiased intention is the pride of place accorded on this page to the Bristol Britannia (the most advanced transport aircraft now in the hands of any operator), whereas the main review is introduced by America's pure-jet challengers, the Boeing 707 and Douglas DC-8.

The Britannia and Comet, DC-8 and -7C, Boeing 707 and Lockheed L.1649—these are the machines that will serve the intercontinental routes in the years ahead, and in them are epitomized the skill and ingenuity of the world's foremost constructors. Though of great bulk and weight (up to 135 tons), their aerodynamic cleanness and available power are such as to permit sustained cruising speeds ranging from the 350 m.p.h. of the DC-7C to the 600 m.p.h. of the pure-jet Douglas

COMMERCIAL AIRCRAFT . . .

and Boeing. These "big six" will establish new standards of economy, and while the turboprop Britannia is at present unequalled among them in operational flexibility, the pure-jet types are less handicapped in this respect than was until recently believed.

Though excelling in speed, range and capacity, the intercontinental versions of the Boeing 707 and DC-8, by reason of their protracted take-off and landing runs and their great weight even at destination, will—unlike the Comet—demand improvements at many airfields intended to receive them. In layout these giants are of the same pattern, having four podded turbojets underslung from a moderately swept wing, and both are remarkable for a high ratio of gross to tare weight. Some interesting variations in detail treatment are discernible, particularly in the matter of control systems. "Straight" or by-pass (Rolls-Royce Conway) turbojets are optional.

The moderate-sweep podded formula promises to implant itself not in the long-range class only, but in the medium category, this being exemplified by the Convair Golden Arrow and Douglas DC-9; but here a sharp and refreshing contrast is presented by France's Caravelle which, though it certainly has podded powerplants, carries them in an eminently sensible location at the rear of the fuselage. Russia's Tu-104—like the Caravelle, a redoubtable competitor in its field—is a rational development of an established bomber type, and commends itself by low initial cost and (it is supposed) early availability.

The extent to which such pure-jet machines will rival the turboprop Vickers Vanguard, late-model Viscounts and Lockheed's Electra is not yet clear, but extensive business has already been transacted by Vickers and Lockheed. Turboprop conversions of the various Convair models (and possibly of Douglas DC-6s and other large aircraft also) may attract valuable orders for Britain's Napier Eland turboprop.

Holding high promise as a mixed-traffic machine or freighter is Lockheed's C-130, planned for military employment but eminently suitable for (and firmly intended for) civil conversion. And who is to say that the mammoth 255,000-lb Douglas C-133, now flying in prototype form, and laid out along the same lines as the C-130, may not eventually be seen in civil colours?

In the so-called feederliner class Holland's Fokker Friendship is regarded with favour by American and other operators and will find increasing acceptance by virtue of its Rolls-Royce Dart turboprops, these being already widely standardized in the Viscount. Darts are specified also for the Aviation Traders Accountant; but in the piston-engined Handley Page Herald both Friendship and Accountant find a doughty challenger—and one having four, instead of two, engines.

Piston engines remain in the running not only in the Herald and in the still-unique Scottish Aviation Twin Pioneer but in the initial versions of the Frye Safari (representing a class of inexpensive, short-haul, short-field, mixed-traffic aircraft) and the Blackburn and General Aircraft Universal. Turboprop conversions, however, are feasible in both instances.

We conclude this note with an expression of regret—that in the pages apportioned to new projects not a solitary example of the large, short-take-off or vertical-take-off aircraft appears, though machines of this class have been brought infinitely nearer practical possibility by the immense power and light weight of the latest turboprops and by new forms (and adaptations of old forms) of high-lift device. That such aircraft will come about is not to be doubted; and that they may yet take the place of the large transport helicopter is a spreading belief.

. . . EXPLANATORY NOTES . . .

The aim of any journal in publishing such a mass of information and statistics as is to be found on the following pages must be standardization of treatment. Unfortunately this is never quite practicable—certainly not in the present state of affairs. For example, direct operating costs, although by no means the only criterion determining whether an aeroplane will make money or become a liability, are of sufficient importance for us to have included appropriate curves wherever possible. Yet they are based on so many different methods and are worked out on such varying parameters (such as dollars per 2,000-lb statute mile or pence per available seat nautical mile) as to render comparison an onerous task. For the record, the following theme has been adhered to, as far as practicable:—

1. All gallonages are Imperial (Imp. gal=1.2 U.S. gal), except for the figure appearing on the DC-7C payload/range curve on page 52.

2. All performance figures, unless otherwise stated, are based on International Standard Atmosphere conditions at Sea Level (for field performance) at maximum take-off weight (for take-off) and maximum landing weight (for landing); climb figures are for maximum weight in the clean condition and cruise figures are for a clean aircraft with gills closed, ice-protection systems inoperative and no unusual excrescences.

3. Payload/range curves are based on information supplied by the manufacturer, and the different procedures adopted by different companies make direct comparison inadvisable without carefully studying the quantities plotted. In general the capacity payload in pounds is plotted against stage length (sometimes termed sector distance), the latter being in either statute or nautical miles (n.m.=1.15 st. miles); in certain cases, however, the x-axis represents range, which may be more than 50 per cent greater than the maximum stage-length which can be flown. Wherever possible the assumptions and allowances made are quoted; manœuvre fuel is normally that expended in taxying and in other positioning without making good any distance towards the destination.

4. Costs are also subject to variation and wherever possible the method used and the assumptions made are quoted. Where no method is stated it is generally safe to assume that the 1955 A.T.A. method has been employed for American machines and the latest S.B.A.C. method (a rather more rigorous treatment) on British aircraft.

5. In most cases the large cut-away drawing shows a typical version of each aircraft. Although most of these drawings do, in fact, depict aircraft exactly as they will be bought by one particular operator the customer has not been named, except in certain cases where a note is added to the caption. Each of these drawings has been prepared specially for this issue, with the exception of four which are revisions of drawings published in 1955. As far as we ourselves are concerned, none of the material is conjectural.

6. Seating plans have in most cases been chosen to depict a configuration different from that shown in the large drawing.

7. Three-view general-arrangement drawings are not to a common scale.

8. In many of the descriptions station numbers are used to identify locations. These are invariably distances in inches from a reference datum; for example, station 620 in the Boeing 707 is 620 inches from the nose.

9. The following further notes are provided by way of amplification, certain additional information having become available since the rest of this issue closed for press:—

a. The fuel tankage of the Comet 4 has been revised and the total capacity is now 8,950 gallons (not 8,766) of usable fuel. There is only one large integral tank in the extension wing and this is between the spars.

b. (Page 21) The text headed "Britannia developments" reflects the thinking of Bristol Aircraft at this time. In spite of a report to the effect that the company are actively considering a pure-jet version of the Britannia, with a new wing and four Bristol Olympus engines, there is no intention of departing from the turboprop until the way can be seen to making a really big advance in performance, perhaps into the supersonic field.

c. (Page 16) The item numbered 78 in the key to the DC-8 drawing should read "0.064in" and "0.063in."

d. (Page 52) The DC-7C payload/range curve gives a tankage in U.S. gallons (7,824). The cost curves are in dollars per mile and cents per 200-lb-mile (not cents per lb-mile).

e. It is reiterated that Handley Page have effected certain detail changes to the Herald (page 59), particularly in the electrical system, as noted in the text. It will shortly be possible to describe these changes.

f. It will also shortly be possible to report upon Lockheed's revised calculations concerning the Electra (page 39) at the increased weight of 113,000 lb. Detail changes are still being made to this aircraft and they are sufficient to render the April 1956 figures inapplicable.

g. (Page 47) Since the Friendship performance data went to press, Fokker have announced a ten per cent improvement in take-off performance. Field length is reduced from 3,800ft to 3,400ft. This is at a weight of 33,000 lb; at the gross weight of 34,520 lb, field length is reduced from 4,200ft to 3,850ft.

AN INDEX WILL BE FOUND ON PAGE 72

Airliners of the World

BOEING 707

BOEING AIRPLANE COMPANY, SEATTLE, WASHINGTON.

ON a number of counts the Boeing Airplane Company can be considered the largest aircraft firm in the world. Certainly they have unmatched experience in the development of large, long-range, high-altitude, high-speed aircraft, and it is logical that they should build a large jet transport.

With the Boeing 247 of 1932 the company produced the first "modern" transport, with metal skin, a cantilever monoplane wing and retractable undercarriage; yet by 1937 this type of machine was almost monopolized by Douglas and Lockheed. Similarly, the Boeing 307 of 1938 was the first high-altitude pressurized airliner; yet the same competitors obtained the lion's share of the civil market for such machines after World War 2. Now, with the 707, Boeing are the first to offer a really large, long-range jet transport; and, unlike the previous "firsts," this design has already reaped a handsome commercial reward.

Serious thinking of jet transports has been going on at Seattle for a decade. Many hundreds of sizes and configurations have been examined, and the general layout of a 100-ton machine, with four 10,000 lb-thrust engines in separate nacelles carried on a 35-deg swept wing, was reached in October 1949. A year later the first proposals were submitted to operators and by the summer of 1952 Boeing had taken the decision to invest £5.35m of their own money in the construction of a prototype which was to serve both for future airliners and for a jet tanker which Boeing conceived as a replacement for the KC-97 with Strategic Air Command. Manufacture of details began in October 1952 and the machine, designated Model 367-80, flew in July 1954. It has now logged rather more than 500 hours and completed all basic testing.

Boeing were successful in gaining the contract for several hundred tankers, with the designation KC-135. These are now in full production at Renton and the first machine off the line is about to fly.

The KC-135 is a larger and heavier machine than is the -80 prototype, and the airliner has grown correspondingly. For domestic operations the basic machine is the 707-120, powered by Pratt and Whitney JT3C-4s of 12,500 lb thrust. The 707-220 is a basically similar airframe matched to the increased thrust of the Pratt and Whitney JT4A, Rolls-Royce Conway or Bristol Olympus, and designed to cruise at up to 608 m.p.h. Finally, the basically redesigned 707-320 Intercontinental is dimensionally larger and substantially heavier, although it is designed for the same power as is the 220. It is at present largely a paper aeroplane only, although several firm orders have been placed for it. Boeing are also offering a variant of the 707-326 to M.A.T.S., at a gross weight of up to 310,000 lb, landing limit of 210,000 lb and empty weight of 122,000 lb (cargo) or 130,000 lb (passenger); engines would be J75s (military JT4A) and cargo capacity 60,000 lb. Except where otherwise stated, the following refers solely to the 707-120.

AIRFRAME. Essentially, the Boeing 707 is a completely traditional structure formed into a modern shape. Stress levels are conservative and there is practically no integrally stiffened skin, spot-welding, titanium or bonding. Boeing precepts of fail-safe design have already been described at length (for example in our issue of February 11, 1953) and render catastrophic tearing virtually impossible.

Fuselage. The fuselage is built in four sections. The first extends from the front pressure bulkhead to behind the nosewheel bay; the next, and largest, piece terminates at the wing trailing edge; the third section runs back to the rear pressure bulkhead and the final piece is the extreme tail, which does not include any of the empennage.

Most of the fuselage structure is identical to that of the KC-135, although in the tanker the upper-bubble radius is 72in, two inches less than in the 707. Frames and stringers are all standard rolled sections of various channel or angle forms. Skin joints occur along strong longitudinal members or frames and are reinforced with doublers. The heaviest frames are those picking up the wing spars at stations 620* and 820; these are heavy extrusions attached to the spars by forgings. A conventional floor structure of transverse beams and longitudinals is built in at the intersection of the two bubbles, the portion of floor above the wing being made integral with the wing.

**See note 8 opposite.*

All doors above the floor—two main doors to port with slightly less wide service doors or emergency exits to starboard—are of the plug type, wider than their frames. When shut they are also of greater depth than their frames but the upper and lower edges of each door can be folded inwards and down on parallel linkages to reduce the effective depth of the door, which can then slide out edge-ways through its opening pivoting on the ends of hinged arms. Underfloor freight and service compartments are provided with simple doors on the starboard side, arranged to push in and slide on rails. Windows are very small (9in × 12½in) and are—unusually—spaced one per 20in frame.

Wing. There are two spars, with heavy sheet webs, stiffened by vertical angles, and extruded booms, the latter being of a T-form above and an angle below. Each complete wing comprises a port and starboard plane bolted to a centre section of the same width as the fuselage.

The rear spar runs straight as far as a production break at station 725, just outboard of the outer nacelles. It then adopts an increased angle of sweep but still converges gently with the front spar. From immediately outboard of the low-speed ailerons the metal tip is detachable about a line perpendicular with the rear spar. Owing to the considerable chordal separation of the spars there are many closely spaced ribs, the majority being unperforated heavy-gauge assemblies at 90 deg to the rear spar, with multiple riveted angle stiffeners. Around these ribs are attached extruded stringers, of angle or channel section, the skin being flush-riveted to the latter. Tapered-sheet skin is not used.

Nearly all the space between the spars forms giant integral tanks, the fuel being allowed to circulate through the spaces between the ribs and skin left by the depth of the stringers. Multiple inspection cut-outs are provided in the under-surface, sealed by doors screwed to rivet/nut units around their peripheries. Inboard of the inner nacelles the rib alignment changes progressively until it is fore-and-aft at the root. Several of the inner ribs have large rectangular cut-outs spanned by the vertical stiffening angles. From the root to the break-joint the underside of the leading edge hinges for access to the interior.

Tail. The fin, which is built separately from the fuselage, has two main spars and a third member along the line of the rudder hinges. The multiple plate ribs change direction at the second spar, those in line with the rudder hinges being of heavier construction.

Like the fin, the variable-incidence tailplane has two main spars and multiple plate ribs with flanged lightening holes, together with heavy ribs carrying the elevator hinges. Aft of the rear spar is a secondary structure housing the large elevator balance panels which waft up and down between the ribs. Each half-tailplane is bolted up to a centre-section box free to tilt in a rectangular cut-out in the fuselage. The centre box is bolted to a pair of forged trusses hinged along a transverse axis behind the rear spar (see "Flying Controls" overleaf).

Pods. The nacelle struts are slung from fore-and-aft strong ribs, the outer such ribs having a cruciform joint with the "normal" (i.e., perpendicular to the rear spar) rib carrying the outer flap tracks. On the front spar at each strut-position is bolted a large forged anchor providing root-fittings for the two strut spars. Below this forging there extends a strong frame, the lower end of which is triangulated back by a compression tube bolted to the underside of the fore-and-aft rib. The struts are completed by multiple, substantially vertical, chordwise members, two of which are heavy frames carrying the powerplant itself. On the Pratt and Whitney JT3C there are mounting pick-ups on top of the compressor inter-spool section, which are attached to the front strut-frame via a forged yoke and braced by a forged stay on each side. Forged attachments also pick up at the top of the turbine-support casing.

In its production form the nacelle strut extends right forward to terminate at a ram intake to the cabin-air turbo-compressors immediately above each main intake. The oil coolers on the JT3C nacelle are mounted on the lower flanks of the powerplants and are fed from separate intakes. Nacelle skinning is likely to be of magnesium to allow it to burn off in the event of an engine fire.

Undercarriage. The main legs are hinged to massive trunnions held against the rear of the wing box between forged fore-and-aft members known as "beaver tails" which lie along the top and bottom surfaces of

Airliners of the World

BOEING 707

the wing, through-bolted to a strong rib. Each beaver tail projects from the line of the skin and fades out midway between the wing spars; the lower pair are in tension and the upper in compression, so that the main gear is, in effect, held in a pair of outsize long-nose pliers.

Each main leg is pulled inwards by a hydraulic jack mounted in a walking beam hinged to a link anchored to the edge of the fuselage floor. The legs are braced by radius rods which are hinged nutcracker-fashion and broken by *ad hoc* jacks picking up on the deep fuselage keel web. According to design weight the tyre pressure varies from 128 to 145 lb/sq in. All wheel-doors have individual jacks and the nose gear retracts forwards and is steerable by twin cylinders to give a turning radius of 21ft about the inner bogies.

Flying Controls. As a result of the great experience with the B-52 bomber Boeing have evolved a completely manual system for the 707, which has been described by several airline captains as "perfection." The rudder is a simple surface actuated by aerodynamic tabs *via* cables incorporating automatic tension-regulating units. The elevators are similar and are used in conjunction with the powered (with manual stand-by) trimming tailplane, driven by an electric screw-jack.

Lateral control is less conventional, partly owing to the fairly substantial angle of sweep on the wing. At low speeds, lowering of the flaps unlocks low-speed ailerons, which are normal surfaces carried on a sub-spar outboard of the wing break at station 725 and operated manually, by tabs. At high speeds these are locked and lateral control is effected by high-speed ailerons and spoilers. The former are relatively small surfaces between the flap portions, moved manually by spring tabs and provided with gust dampers for speeds up to 70 knots. The spoilers are fitted in four sections above each wing. They can be flicked open together, to act as speed brakes, or differentially, to increase rate of roll; they are permanently linked to the aileron circuit.

All flying controls are sealed by a novel arrangement of internal pressure-balance panels. These broadly consist of inter-rib sections of flat plates hinged to chordal extensions from the leading edge of the moving surface and arranged to move with the surface inside balance-chamber boxes formed by the fixed skins and ribs. The fixed structure in the wing behind the rear spar, although secondary, is made rigid to form accurate housings for these panels. The upper fixed skins are stabilized by spanwise bonded channels and the lower skins are honeycomb-filled sandwiches, better able to withstand the intense high-frequency buffet from the engines.

Double-slotted flaps are fitted in two portions on each wing. The outer flap sections are driven through screw-jacks and torque tubes geared to a hydraulic motor on the aft face of the lower part of the fuselage rear-spar frame. The inner portions are similarly driven from an independent system, bevel boxes in which also actuate the small split "fillet flaps" at the trailing-edge roots. Emergency actuation is electric.

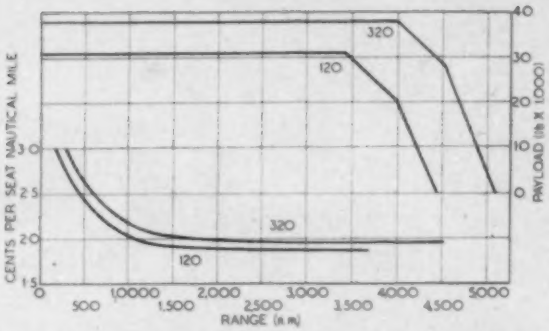
Each flap portion runs out on steel tracks to increase area. Production 707s have straight (i.e., unrecessed) flap leading edges, with spanwise stringers, a single spar and honeycomb-stabilized skin. Ahead of the flaps the underside of the wing is terminated at a cove-lip door which hinges up when the flaps are down; as the flaps return to their housed position they engage the door and push it down to seal the chordal gap which would otherwise exist. Position-indicators are provided for each flap section and lateral control can be retained with any one section asymmetric.

POWERPLANTS. On the 707-120 the standard engine is the Pratt and Whitney JT3C-4 turbojet, with a wet rating of 13,000 lb. This is a commercial variant of the well-known J57, a large and fairly weighty engine with tandem compressors operating at the very high pressure ratio of 12.5 : 1. It has a can-annular combustion system and most of the accessories are grouped under the casing of the rear, high-pressure compressor. Oil is contained in a 5.75 gal saddle tank above the front low-pressure casing and is cooled in tubular coolers mounted low on each side of the nacelle (in the -80 prototype the oil coolers are in the fairing on the front of the intake-hub).

All JT3C-powered machines will be equipped for water injection for use on all full-load take-offs at ambient temperatures over about 50 deg F. Approximately 350 gal water will be carried (in a position yet to be finalized on the -320; on the -120 it will be in the wing tips and centre section) and supplied by electrically-driven pumps taking a total of 40 kVA. All the water available will be expended in the first two minutes of flight to obviate freezing problems.

Very extensive development is continuing with a view to reaching an optimum design of noise-reducing, thrust-reversing propelling nozzle. In co-operation with the N.A.C.A., Rolls-Royce and other agencies, several attractive arrangements have been investigated, and at least one nozzle has been flown on the -80. Engine starting can be effected electrically or by a monofuel or pneumatic turbo-starter.

Power for the -220 and -320 aircraft will be provided by the Pratt and Whitney JT4A-3, a commercial development of the large and weighty J75 turbojet rated at approximately 16,000 lb thrust. In geometry this engine resembles the JT3C and the nacelle configuration will be similar, although each equipped nacelle will weigh at least



Payload/range: long-range cruise upper limit 40,000ft; allowances for t-o, climb and acceleration, no credit for descent; no wind, N.A.C.A. standard day; reserves 17,000 lb (320), 16,000 lb (120). Costs: 1955 A.T.A. on 7-year depreciation; overseas with flight crew of four.

2,000 lb more. Boeing have also prepared specifications for aircraft powered by the Rolls-Royce Conway (707-420 and -520) and Bristol Olympus 511.

SYSTEMS. Air Conditioning. At the junction of each strut leading-edge and main engine intake a ram intake is provided admitting air to turbo-compressor sets driven by air bled from the first spool of the engines. The fresh air from these units is ducted along the face of the front spar to the centre section, where it turns aft and passes to a primary heat exchanger served by ram intakes at the forward end of the belly fairings over the main-gear bays. The cabin air can then pass either direct to distribution manifolds or by way of an air-cycle cooling unit, secondary heat exchanger and water-separator. The secondary heat exchanger is fed from a bifurcation in the same belly intake; its air is dumped overboard immediately forward of the rear spar and a vacuum ground-cooling connection is provided at the same point.

Cabin manifolds run longitudinally from the central bay and feed branches between each pair of frames. Air passes between each window sandwich and enters the cabin beneath the baggage racks, a separate duct feeding the flight deck. Used air is extracted at floor-level, taken to freight-hold floor-level and passed back to the central bay. Outflow valves are situated at the front-spar bulkhead (2), rear-spar bulkhead (1) and under the centre-line near the rear door (1).

Fuel. Reading in from the port tip the tankage comprises: a tank (not used for storage); port reserve tank (361 gal) from the outer end of the low-speed aileron to inboard of the outer strut (through the break at sta.725); No. 1 tank (1,946 gal) to a point inboard of the inner strut; No. 2 tank (1,894 gal) to the root rib; the centre section (4,460 gal); and corresponding tanks to starboard. Except for the centre-section tank all tankage is integral.

Dry bays (i.e., without fuel) are provided immediately inboard of each strut. Pressure-fuelling sockets are provided beneath the wing together with gravity fillers above tanks 1, 2, 3 and 4. Electric dump pumps can rapidly evacuate the centre-section tank in the event of an emergency at an early stage in the flight plan. Shut-off valves, pressure switches and defuelling connections are provided in the inner dry bays. The tanks are vented through the spanwise stringer channels.

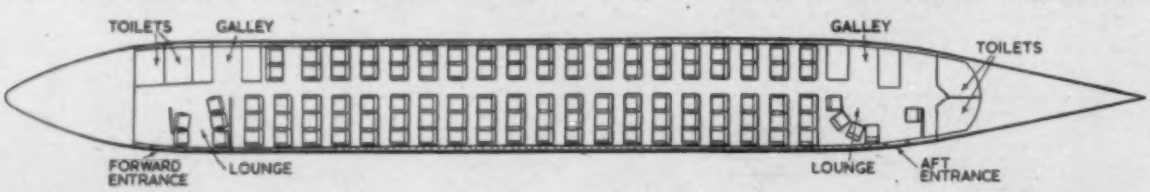
Hydraulics. A pump on each engine energizes a 3,000 lb/sq in system filled with low-temperature Skydrol 500 fluid. Hydraulic services are provided for the flaps, undercarriage, spoilers, wheel brakes, nosewheel steering and (if fitted) windscreen wipers. Centralized hydraulic panels are provided in the main undercarriage bays.

Electrics. A 30 kVA alternator is mounted on each engine, driven through a Sundstrand hydraulic coupling. All power is generated at 115V, three-phase, 400 c.p.s., and the four alternators can be paralleled or, in the event of a malfunction, can individually serve specific loads, such as the fuel booster pumps, stand-by hydraulics and flap motors.

Ice Protection. Hot air for this purpose is extracted from the delivery of the high-pressure spool of the JT3C at about 700 deg F, and ducted along the leading edge of the wing, heating being continuous. A further supply of bleed air is passed around the engine intakes. Electric heater mats are fitted on the leading edge of the tailplane and Nesa glass is fitted in the forward-facing panels of the flight deck.

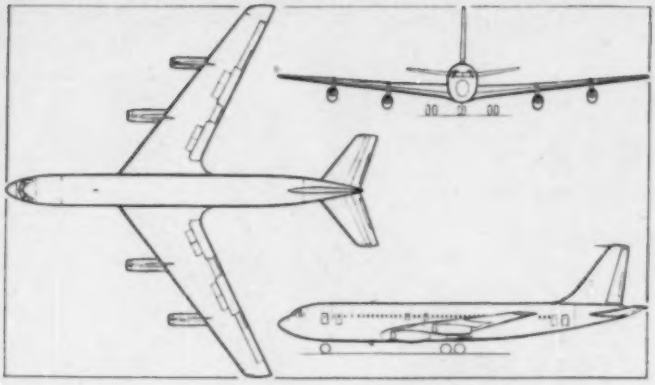
FLIGHT EQUIPMENT. The cockpit is somewhat smaller than on the spacious Boeing 377, but it is well-planned to S.A.E. recommendations and has found favour with the hundred-plus airline captains who have flown the -80. A seat for a flight engineer is provided behind the pedestal, his panels being to starboard. One window on each side forms a direct-vision panel, large enough to serve for emergency crew-escape. At the time of writing hydraulic wipers are specified.

The following is a selection of standard radio equipment: R.C.A. search radar AVQ-10 in the nose, with a glide-slope horseshoe mounted immediately above; Döppler true-airspeed aerials at the bottom of the front pressure bulkhead; an A.T.C. transponder in the flight-deck roof;



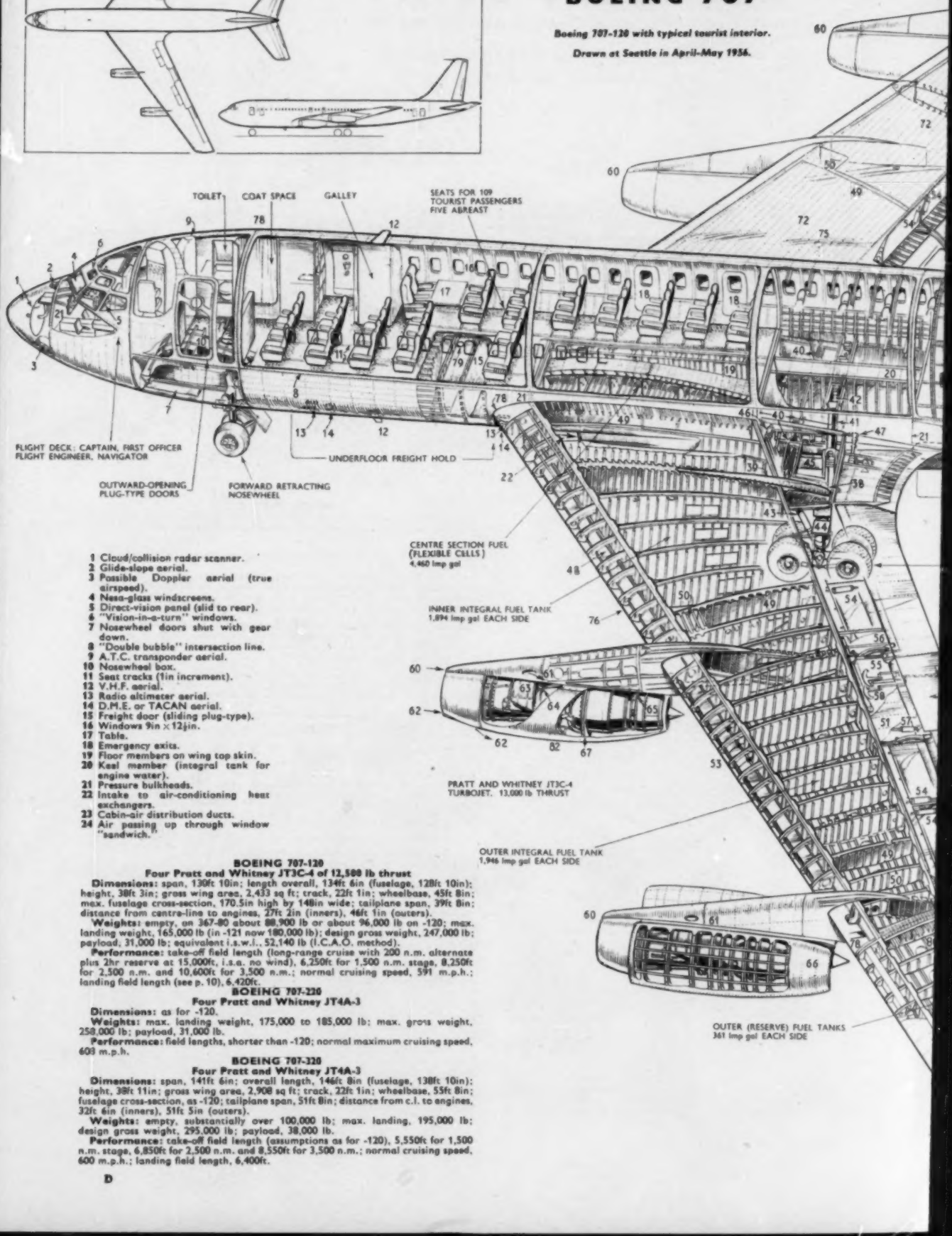
Airliners of the World

BOEING 707



Boeing 707-120 with typical tourist interior.

Drawn at Seattle in April-May 1956.


TOILET
COAT SPACE
GALLEY
SEATS FOR 109 TOURIST PASSENGERS FIVE ABREAST
FLIGHT DECK: CAPTAIN, FIRST OFFICER FLIGHT ENGINEER, NAVIGATOR
OUTWARD-OPENING PLUG-TYPE DOORS
FORWARD RETRACTING NOSEWHEEL
UNDERFLOOR FREIGHT HOLD
CENTRE SECTION FUEL (FLEXIBLE CELLS) 4,460 Imp gal
INNER INTEGRAL FUEL TANK 1,894 Imp gal EACH SIDE
PRATT AND WHITNEY JT3C-4 TURBOJET. 13,000 lb THRUST
OUTER INTEGRAL FUEL TANK 1,946 Imp gal EACH SIDE
OUTER (RESERVE) FUEL TANKS 361 Imp gal EACH SIDE

1 Cloud/collision radar scanner.
2 Glide-slope aerial.
3 Possible Doppler aerial (true airspeed).
4 Nasa-glass windscreens.
5 Direct-vision panel (slid to rear).
6 "Vision-in-a-turn" windows.
7 Nosewheel doors shut with gear down.
8 "Double bubble" intersection line.
9 A.T.C. transponder aerial.
10 Nosewheel box.
11 Seat tracks (1in increment).
12 V.H.F. aerial.
13 Radio altimeter aerial.
14 D.M.E. or TACAN aerial.
15 Freight door (sliding plug-type).
16 Windows 9in × 12½in.
17 Table.
18 Emergency exits.
19 Floor members on wing top skin.
20 Keel member (integral tank for engine water).
21 Pressure bulkheads.
22 Intake to air-conditioning heat exchangers.
23 Cabin-air distribution ducts.
24 Air passing up through window "sandwich."

BOEING 707-120
Four Pratt and Whitney JT3C-4 of 12,500 lb thrust

Dimensions: span, 130ft 10in; length overall, 134ft 6in (fuselage, 128ft 10in); height, 38ft 3in; gross wing area, 2,433 sq ft; track, 22ft 1in; wheelbase, 45ft 8in; max. fuselage cross-section, 170.5in high by 148in wide; tailplane span, 39ft 8in; distance from centre-line to engines, 27ft 2in (inners), 46ft 1in (outers).

Weights: empty, an 367-80 about 88,900 lb or about 96,000 lb on -120; max. landing weight, 165,000 lb (in -121 now 180,000 lb); design gross weight, 247,000 lb; payload, 31,000 lb; equivalent i.s.w.i., 52,140 lb (I.C.A.O. method).

Performance: take-off field length (long-range cruise with 200 n.m. alternate plus 2hr reserve at 15,000ft, i.s.a. no wind), 6,250ft for 1,500 n.m. stage, 8,250ft for 2,500 n.m. and 10,600ft for 3,500 n.m.; normal cruising speed, 591 m.p.h.; landing field length (see p. 10), 6,420ft.

BOEING 707-220
Four Pratt and Whitney JT4A-3

Dimensions: as for -120.

Weights: max. landing weight, 175,000 to 185,000 lb; max. gross weight, 258,000 lb; payload, 31,000 lb.

Performance: field lengths, shorter than -120; normal maximum cruising speed, 603 m.p.h.

BOEING 707-320
Four Pratt and Whitney JT4A-3

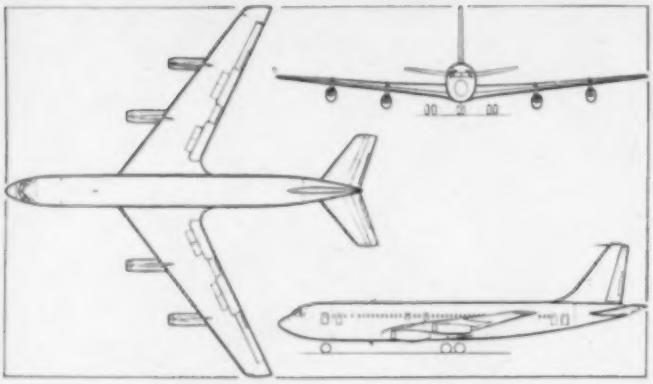
Dimensions: span, 141ft 6in; overall length, 146ft 8in (fuselage, 138ft 10in); height, 38ft 11in; gross wing area, 2,908 sq ft; track, 22ft 1in; wheelbase, 55ft 8in; fuselage cross-section, as -120; tailplane span, 51ft 8in; distance from c.l. to engines, 32ft 6in (inners), 51ft 5in (outers).

Weights: empty, substantially over 100,000 lb; max. landing, 195,000 lb; design gross weight, 295,000 lb; payload, 38,000 lb.

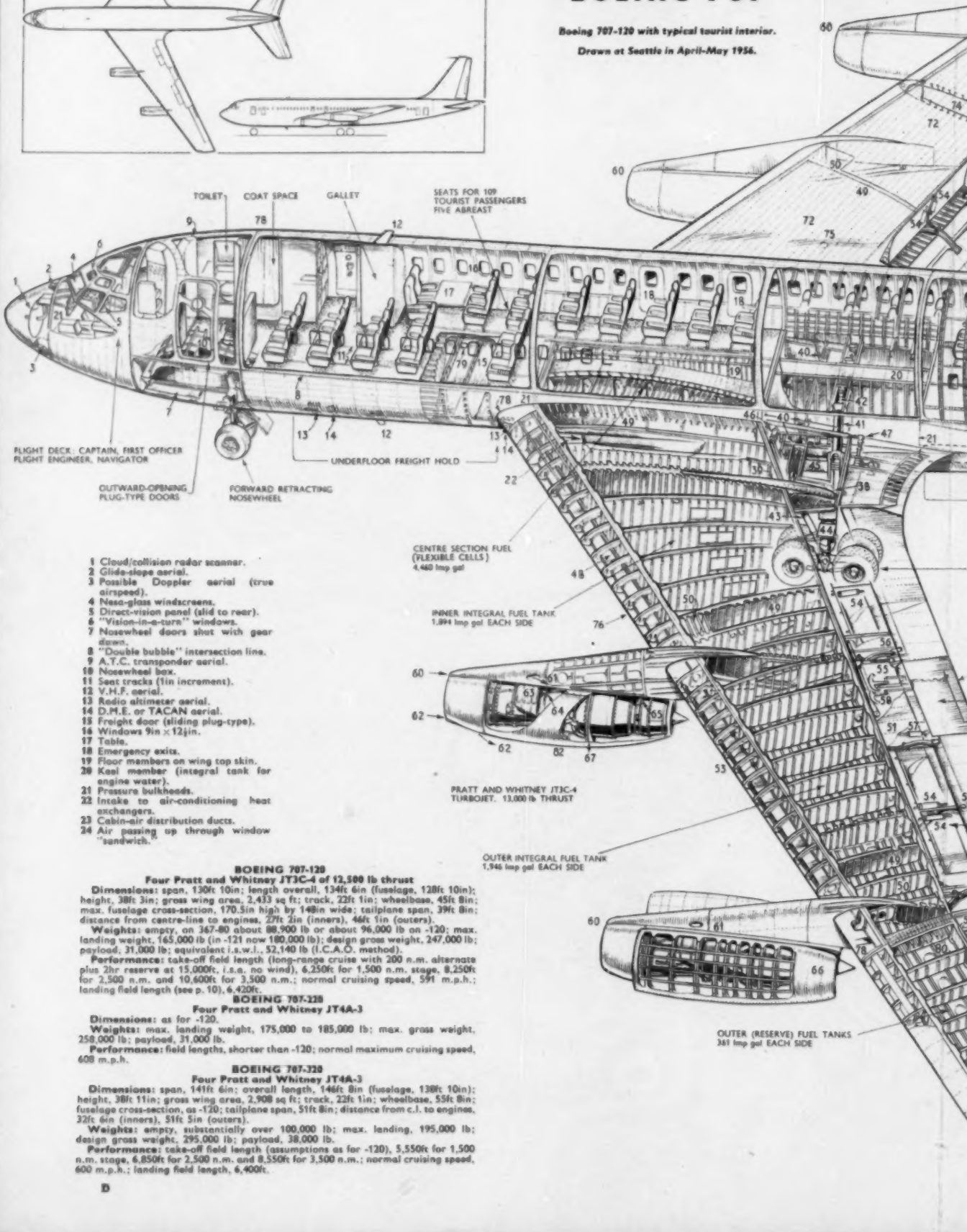
Performance: take-off field length (assumptions as for -120), 5,550ft for 1,500 n.m. stage, 6,850ft for 2,500 n.m. and 8,550ft for 3,500 n.m.; normal cruising speed, 600 m.p.h.; landing field length, 6,400ft.

Airliners of the World

BOEING 707



Boeing 707-120 with typical tourist interior.
Drawn at Seattle in April-May 1956.


TOILET
COAT SPACE
GALLEY
SEATS FOR 109 TOURIST PASSENGERS FIVE ABREAST
FLIGHT DECK: CAPTAIN, FIRST OFFICER FLIGHT ENGINEER, NAVIGATOR
OUTWARD-OPENING PLUG-TYPE DOORS
FORWARD RETRACTING NOSEWHEEL
UNDERFLOOR FREIGHT HOLD
CENTRE SECTION FUEL (FLEXIBLE CELLS) 4,460 Imp gal
INNER INTEGRAL FUEL TANK 1,894 Imp gal EACH SIDE
PRATT AND WHITNEY JT3C-4 TURBOJET. 13,000 lb THRUST
OUTER INTEGRAL FUEL TANK 1,946 Imp gal EACH SIDE
OUTER (RESERVE) FUEL TANKS 361 Imp gal EACH SIDE

1 Cloud/collision radar scanner.
2 Glide-slope aerial.
3 Possible Doppler aerial (true airspeed).
4 Nasa-glass windscreens.
5 Direct-vision panel (slid to rear).
6 "Vision-in-a-turn" windows.
7 Nosewheel doors shut with gear down.
8 "Double bubble" intersection line.
9 A.T.C. transponder aerial.
10 Nosewheel box.
11 Seat tracks (1in increment).
12 V.H.F. aerial.
13 Radio altimeter aerial.
14 D.M.E. or TACAN aerial.
15 Freight door (sliding plug-type).
16 Windows 9in x 12½in.
17 Table.
18 Emergency exits.
19 Floor members on wing top skin.
20 Keel member (integral tank for engine water).
21 Pressure bulkheads.
22 Intake to air-conditioning heat exchangers.
23 Cabin-air distribution ducts.
24 Air passing up through window "sandwich."

BOEING 707-120
Four Pratt and Whitney JT3C-4 of 12,500 lb thrust

Dimensions: span, 130ft 10in; length overall, 134ft 6in (fuselage, 128ft 10in); height, 38ft 3in; gross wing area, 2,433 sq ft; track, 22ft 1in; wheelbase, 45ft 8in; max. fuselage cross-section, 170.5in high by 149in wide; tailplane span, 39ft 8in; distance from centre-line to engines, 27ft 2in (inners), 46ft 1in (outers).

Weights: empty, on 367-80 about 88,900 lb or about 96,000 lb on -120; max. landing weight, 165,000 lb (in -121 now 180,000 lb); design gross weight, 247,000 lb; payload, 31,000 lb; equivalent i.a.w.l., 52,140 lb (I.C.A.O. method).

Performance: take-off field length (long-range cruise with 200 n.m. alternate plus 2hr reserve at 15,000ft, *i.s.a.* no wind), 6,250ft for 1,500 n.m. stage, 8,250ft for 2,500 n.m. and 10,600ft for 3,500 n.m.; normal cruising speed, 591 m.p.h.; landing field length (see p. 10), 6,420ft.

BOEING 707-220
Four Pratt and Whitney JT4A-3

Dimensions: as for -120.

Weights: max. landing weight, 175,000 to 185,000 lb; max. gross weight, 258,000 lb; payload, 31,000 lb.

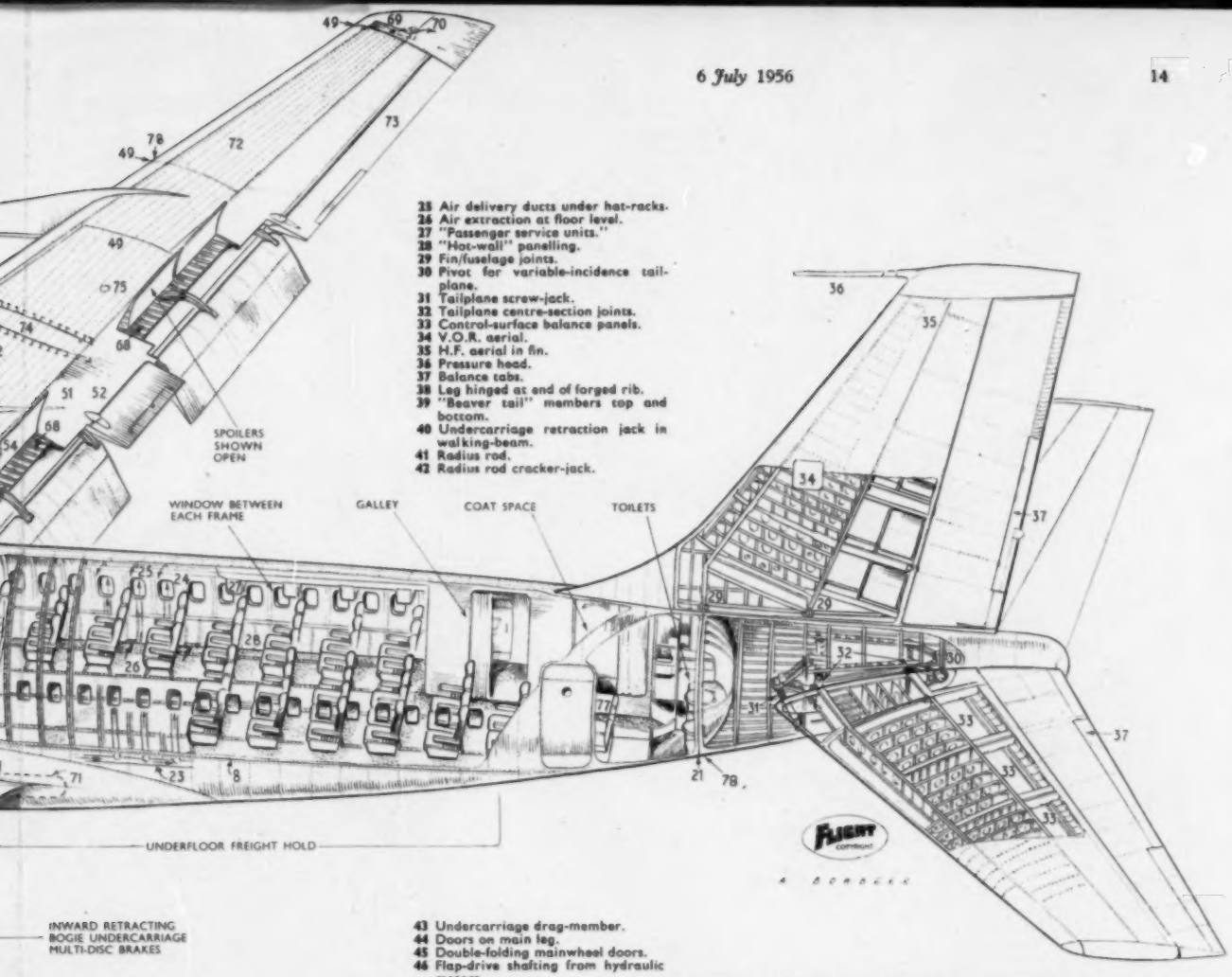
Performance: field lengths, shorter than -120; normal maximum cruising speed, 608 m.p.h.

BOEING 707-320
Four Pratt and Whitney JT4A-3

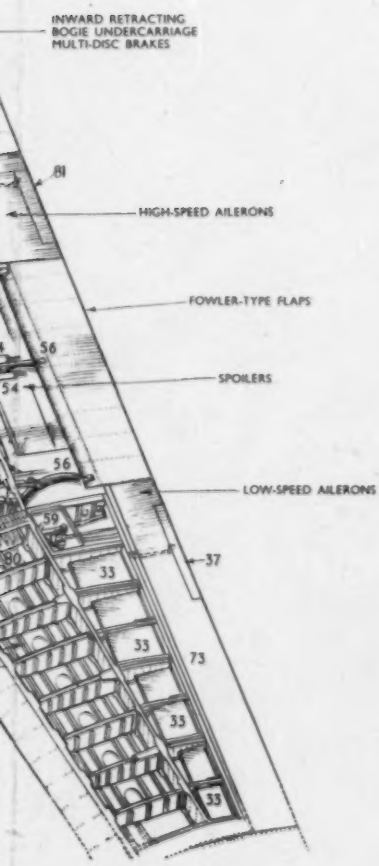
Dimensions: span, 141ft 6in; overall length, 146ft 8in (fuselage, 138ft 10in); height, 38ft 11in; gross wing area, 2,908 sq ft; track, 22ft 1in; wheelbase, 55ft 8in; fuselage cross-section, as -120; tailplane span, 51ft 8in; distance from c.l. to engines, 32ft 6in (inners), 51ft 5in (outers).

Weights: empty, substantially over 100,000 lb; max. landing, 195,000 lb; design gross weight, 295,000 lb; payload, 38,000 lb.

Performance: take-off field length (assumptions as for -120), 5,550ft for 1,500 n.m. stage, 6,850ft for 2,500 n.m. and 8,550ft for 3,500 n.m.; normal cruising speed, 600 m.p.h.; landing field length, 6,400ft.



25 Air delivery ducts under hat-racks.
26 Air extraction at floor level.
27 "Passenger service units."
28 "Hat-wall" panelling.
29 Fin/fuselage joints.
30 Pivot for variable-incidence tail-plane.
31 Tailplane screw-jack.
32 Tailplane centre-section joints.
33 Control-surface balance panels.
34 V.O.R. aerial.
35 H.F. aerial in fin.
36 Pressure head.
37 Balance tabs.
38 Leg hinged at end of forged rib.
39 "Beaver tail" members top and bottom.
40 Undercarriage retraction jack in walking-beam.
41 Radius rod.
42 Radius rod cracker-jack.



43 Undercarriage drag-member.
44 Doors on main leg.
45 Double-folding mainwheel doors.
46 Flap-drive shafting from hydraulic motors.
47 Fillet-flap shafting (off inner-flap system).
48 Leading-edge inspection panels.
49 Fuel tank end-ribs.
50 Fuel system dry-bay (shut-off valves, defuelling connections and pressure switches).
51 Bonded stiffeners in trailing-edge top surface.
52 Honeycomb sandwich in trailing-edge bottom surface.
53 Hot-air de-icing, double skin full length of leading edge.
54 Spoiler operating jacks.
55 Flap screw-jack.
56 Flap tracks and rollers.
57 Gust damper (70 m.p.h. limit).
58 Aileron/spoiler linkage.
59 Low-speed aileron linkage.
60 Intake to cabin-air turbo-compressor.
61 Outlet from turbo-compressor.
62 Airflow through engine oil-coolers.
63 Oil tank.
64 Main engine mounting.
65 Rear engine "steady."
66 Magnesium cowlings.
67 Firewalls.
68 Cove-lip door (covers gap when flaps up).
69 Fuel system surge-tank.
70 N.A.C.A.-type inlet to tank vent system.
71 Engine-starting air bottle.
72 Two (independent) boost pumps in each tank.
73 Honeycomb-sandwich aileron skins.
74 Typical wing section.
75 Gravity fuel fillers.
76 Pressure-refuelling points on lower surface.
77 Cabin attendants' seats.
78 Production break-lines.
79 Wide-angle lens for freight-hold inspection.
80 Tank inspection panels.
81 Spring tab (full surface movement available for ground test).
82 Sundstrand-driven 30 kVA alternators on all engines.

a low-drag "shark's fin" (Boeing-developed) V.H.F. aerial above the forward fuselage; on the underside of the fuselage (front to rear), a radar-altimeter aerial, D.M.E. or Tacan No. 1 aerial, a second shark's fin, the second radar-altimeter aerial, a suppressed A.D.F. cross, the No. 2 Tacan, a second A.D.F. cross, a marker aerial, and Nos. 1 and 2 A.D.F. sense panels, the latter reaching to station 820; in the sides of the fin are dielectric windows for the V.O.R., and the H.F. aerial is in the fin tip (the KC-135 fin houses AN/APN-69, AN/ARN-14 and AN/ARC-34).

Pilot instrumentation is exceptionally neat, most of the engine instruments being in 2in cases. Radar panels are overhead and radio controls flank the throttle quadrant with its single-lever engine controls. The Sperry Integrated Flight System is standard (*Flight*, January 20, 1956).

PAYLOAD ACCOMMODATION. In the -120 and its similarly dimensional successors, usable cabin space measures about 96ft long by 140in wide. A standard five-abreast layout can seat 108, with two toilets and a galley at each end; by removing five seats a four- or five-seat lounge can be provided at either end. The mock-up at present on view in New York City has two such lounges and 98 seats. At the other extreme of comfort, six-abreast seating can be provided for as many as 125 passengers. Capacities of the underfloor freight holds are 490 cu ft (forward) and 800 cu ft (aft).

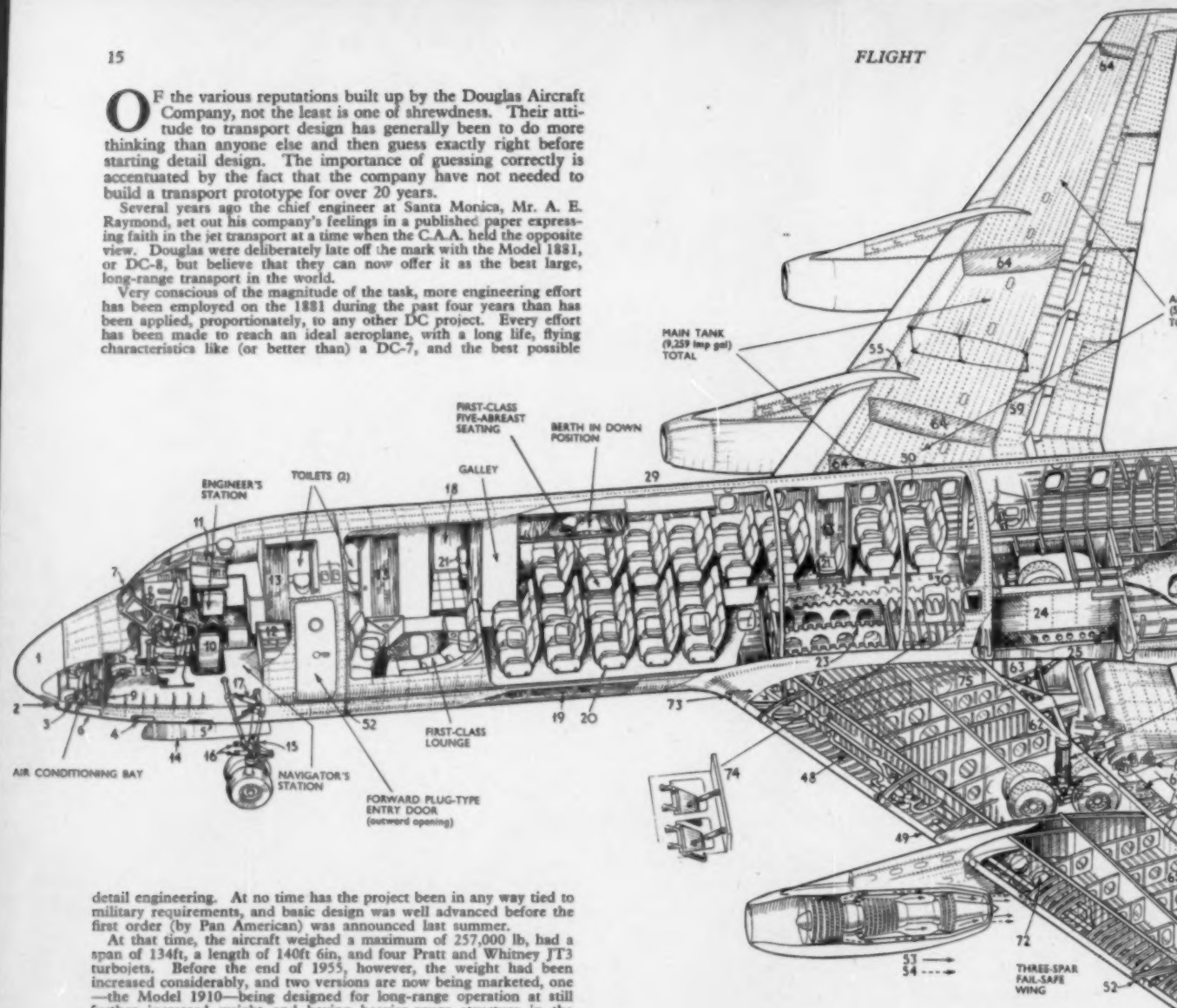
Of the same cross section, but 144in longer, the -320 and its sister ships can seat 122 in a five-abreast configuration with the following at each end: two toilets, galley, coat racks and two tip-up seats. Six-abreast seating provides for a maximum of 147, and various movable bulkheads can divide up the interior into first- and second-class sections. Lounge accommodation can be provided similar to that in the -120. Underfloor freight holds are similar to those of the smaller machine except for an increase in the size of the forward hold to 700 cu ft.

COMMERCIAL HISTORY. The first order was that of Pan American (October 13, 1955), who bought 20 120s for delivery in late 1958 at a price of some £39m; in February the order was altered and extended to comprise six -120s and 17 -320s, at a total of £48.25m. Succeeding orders are as follows: American, November 1955, 30 -120 for March 1959 at £48.25m; Braniff, December 1955, five -220 for October 1959 at £10.7m including spares; Continental, December 1955, four -120 for May 1959 at £7.6m including spares; Air France, December 1955, ten -320 for November 1959 at £25.5m including spares and training; Sabena, December 1955, three -320 for December 1959 at £5.5m, with a fourth added later at £1.9m; T.W.A., February 1956, eight -120 for April 1959 at £12.8m; and Lufthansa, April 1956, four -320 for summer of 1960 at £7.5m.

OF the various reputations built up by the Douglas Aircraft Company, not the least is one of shrewdness. Their attitude to transport design has generally been to do more thinking than anyone else and then guess exactly right before starting detail design. The importance of guessing correctly is accentuated by the fact that the company have not needed to build a transport prototype for over 20 years.

Several years ago the chief engineer at Santa Monica, Mr. A. E. Raymond, set out his company's feelings in a published paper expressing faith in the jet transport at a time when the C.A.A. held the opposite view. Douglas were deliberately late off the mark with the Model 1881, or DC-8, but believe that they can now offer it as the best large, long-range transport in the world.

Very conscious of the magnitude of the task, more engineering effort has been employed on the 1881 during the past four years than has been applied, proportionately, to any other DC project. Every effort has been made to reach an ideal aeroplane, with a long life, flying characteristics like (or better than) a DC-7, and the best possible



detail engineering. At no time has the project been in any way tied to military requirements, and basic design was well advanced before the first order (by Pan American) was announced last summer.

At that time, the aircraft weighed a maximum of 257,000 lb, had a span of 134ft, a length of 140ft 6in, and four Pratt and Whitney JT3 turbojets. Before the end of 1955, however, the weight had been increased considerably, and two versions are now being marketed, one —the Model 1910—being designed for long-range operation at still further increased weight and having heavier-gauge structure in the wing, horizontal tail, aft fuselage and landing gear. Four types of powerplant may be installed, with thrusts ranging from 12,500 to 20,000 lb.

AIRFRAME. Great care has ensured that stresses are generally no higher than those in the DC-7. This is particularly true of the fuselage, in which Douglas have succeeded in using the accumulated experience of the DC-6 and 7 series in making the upper "bubble" of the DC-8 characteristically similar to the piston-engined hull, although on a larger scale.

The philosophy has been to recognize the possibility of eventual fatigue failure (particularly as a result of local damage), but to incorporate "rip-stop" characteristics to prevent dangerous propagation of cracks. The aim is to constrain any failure to follow a generally circular path within each 20in inter-frame section. Other features are the use of advanced bolting and riveting techniques, elimination of eccentricities and small radii, and smooth-tapering, low-stress joints. Many specimens have been investigated, and the company now feel that they have reached the sort of structure which they have been seeking.

Fuselage. Skinning in the fuselage is generally 14 s.w.g. or thinner. This is carried on deep channel frames at 20in centres and riveted Z-stringers, doublers being used to provide multiple load paths in certain regions. Much research has centred on the lap-jointing of skin panels, this being effected through multiple rows of countersunk rivets on heavy channel sections with a sandwiched doubler plate (with pressed stiffening joggles) acting almost as a second skin. Small portions of fuselage have been extensively developed, gradually changing the detail design until the optimum form is made as a complete structure and pressure-tested.

The cross-section is formed from two circular diameters, the upper being the greater, meeting along a slight cusp (the upper radius is 73.5in, centred 17in above the floor; the lower radius is 68.7in with a centre 6.7in above the floor). Full diameters are reached as soon as possible aft of the flight-deck, and are held constant for almost one hundred feet—a fact which will facilitate future "stretching" of the design. The ventral keel between the two main undercarriage bays

1 Search radar dielectric radome.
2 Intake to cabin air system.
3 Cabin-air turbo-compressors (55,000 r.p.m.).
4 Turbine exhaust.
5 Heat-exchanger exhaust.
6 Access door.
7 Nasa glass multi-layer screen (no wipers).
8 Upper window each side.
9 Forward pressure bulkhead.
10 Supernumerary seat.
11 Engineer's panel.
12 Radio racks (air-cooled).
13 Coats.
14 Twin nosewheel doors.
15 Nose gear geometry similar to DC-7.
16 Steering cylinders.
17 Retraction jack.
18 Galley service door.
19 Underfloor hold (doors starboard).
20 Wall-fixed seats.
21 Attendant's seat.
22 Centre-joint butt-strap.
23 Centre section tank ("overwater" Model 1910 only).
24 Centre keel-member (5ft deep).
25 Mainwheel doors (normally closed after undercarriage extension).
26 Windows (16in × 12in).
27 Grille (cabin air in, out at floor level).
28 Passenger-address speaker.
29 Hat-racks.
30 Emergency exits.
31 Emergency door.
32 "Hot wall" panelling.
33 "Up-and-over" inward-opening freight door.
34 Concealed lighting.
35 Integral three-spar fin.
36 Sloping frames.
37 Fibreglass structural (dielectric) isolating.
38 Bonded inner skin.
39 V.O.R. aerial.
40 H.F. aerial.
41 Tailplane screw-jacks.
42 Tailplane hydraulic and electric motors.
43 Tail de-icing trunk.
44 Retractable bumper.
45 Integrally stiffened skin.
46 Fully powered rudder.
47 Manual elevators.
48 Fuel-system runs.

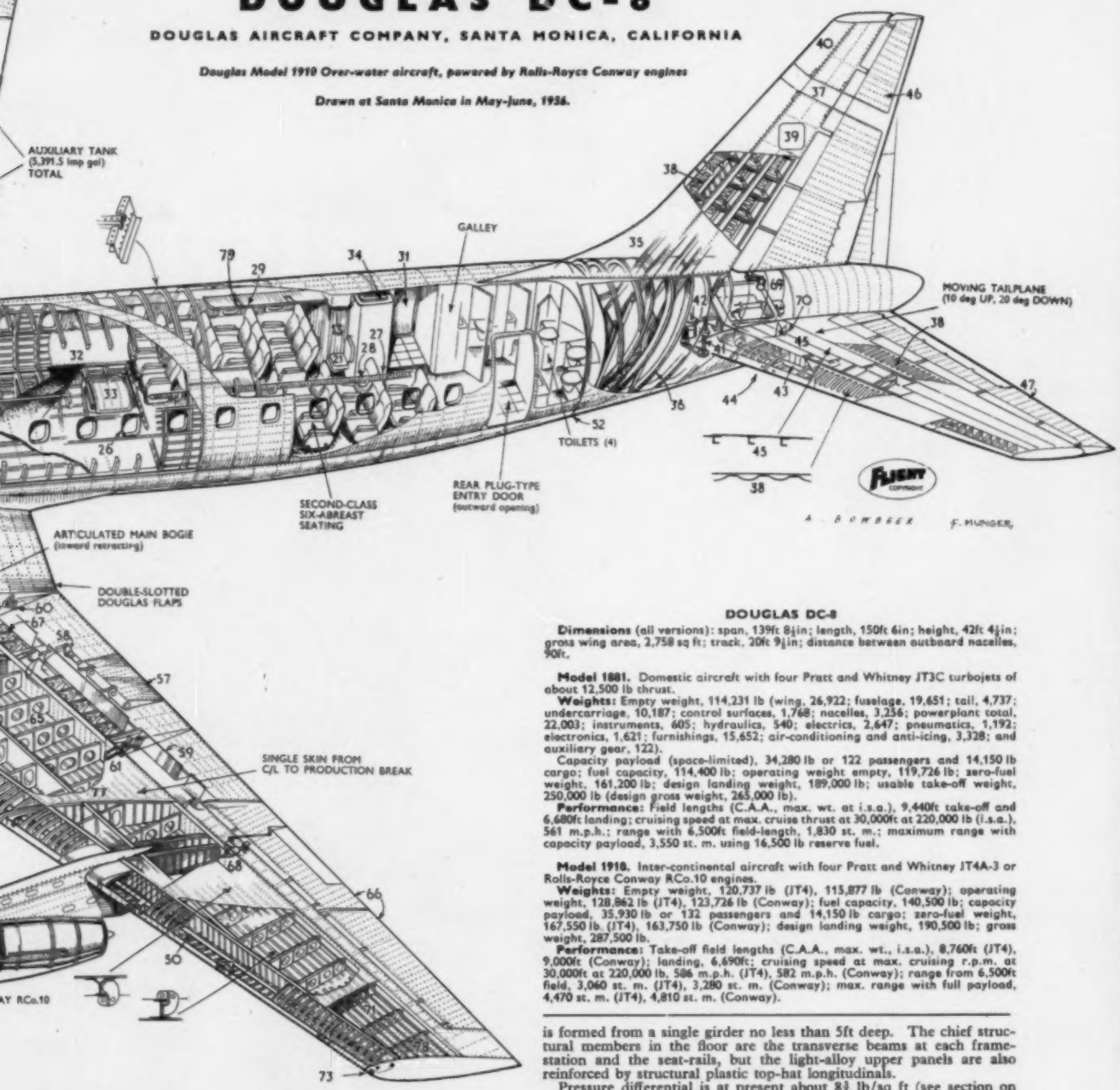
Airliners of the World

DOUGLAS DC-8

DOUGLAS AIRCRAFT COMPANY, SANTA MONICA, CALIFORNIA

Douglas Model 1910 Over-water aircraft, powered by Rolls-Royce Conway engines

Drawn at Santa Monica in May-June, 1956.



DOUGLAS DC-8

Dimensions (all versions): span, 139ft 8¾in; length, 150ft 6in; height, 42ft 4½in; gross wing area, 2,758 sq ft; track, 20ft 9½in; distance between outboard nacelles, 50ft.

Model 1881. Domestic aircraft with four Pratt and Whitney JT3C turbojets of about 12,500 lb thrust.

Weights: Empty weight, 114,231 lb (wing, 26,922; fuselage, 19,651; tail, 4,737; undercarriage, 10,187; control surfaces, 1,768; nacelles, 3,256; powerplant total, 22,003; instruments, 605; hydraulics, 540; electrics, 2,647; pneumatics, 1,192; electronics, 1,621; furnishings, 15,652; air-conditioning and anti-icing, 3,328; and auxiliary gear, 122).

Capacity payload (space-limited), 34,280 lb or 122 passengers and 14,150 lb cargo; fuel capacity, 114,400 lb; operating weight empty, 119,726 lb; zero-fuel weight, 161,200 lb; design landing weight, 189,000 lb; usable take-off weight, 250,000 lb (design gross weight, 265,000 lb).

Performance: Field lengths (C.A.A., max. wt. at i.s.a.), 9,440ft take-off and 6,680ft landing; cruising speed at max. cruise thrust at 30,000ft at 220,000 lb (i.s.a.), 561 m.p.h.; range with 6,500ft field-length, 1,830 st. m.; maximum range with capacity payload, 3,550 st. m. using 16,500 lb reserve fuel.

Model 1910. Inter-continental aircraft with four Pratt and Whitney JT4A-3 or Rolls-Royce Conway RCo.10 engines.

Weights: Empty weight, 120,737 lb (JT4), 115,877 lb (Conway); operating weight, 128,862 lb (JT4), 123,726 lb (Conway); fuel capacity, 140,500 lb; capacity payload, 35,930 lb or 132 passengers and 14,150 lb cargo; zero-fuel weight, 167,550 lb (JT4), 163,750 lb (Conway); design landing weight, 190,500 lb; gross weight, 287,500 lb.

Performance: Take-off field lengths (C.A.A., max. wt., i.s.a.), 8,760ft (JT4), 9,000ft (Conway); landing, 6,690ft; cruising speed at max. cruising r.p.m. at 30,000ft at 220,000 lb, 586 m.p.h. (JT4), 582 m.p.h. (Conway); range from 6,500ft field, 3,060 st. m. (JT4), 3,280 st. m. (Conway); max. range with full payload, 4,470 st. m. (JT4), 4,810 st. m. (Conway).

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49 De-icing duct (cyclic heat).
50 De-icing trunk.
51 Hot-air anti-icing.
52 Production break.
53 Primary (combustion) airflow.
54 By-pass airflow.
55 In-swept pylon tails.
56 Intake to Sundstrand-drive oil-coolers.
57 Portion of flap (held up to clear jet blast).
58 Linkage to 57.
59 Lift spoilers (operated by nose-wheel-to-ground contact).
60 Multiple scissor links (inner to outer flap).
61 Flap-operating linkage.
62 Main-leg sub-frame.
63 Main-leg retraction jack.
64 Tank-bay end-ribs (full depth).
65 Un-notched ribs (not full depth).
66 Divided powered ailerons (inner = high speed, outer = low speed).
67 Bonded trailing-edge structure.
68 Aileron power unit (emergency manual tab).
69 Rudder power unit.
70 Tailplane hinge-axis.
71 Tank for injection-water (outers in tip, inners in centre section).
72 Fire-suppression bottles (378 cu in C.B. and Freon).
73 Leading-edge venting.
74 Air brakes under centre section.
75 Skin thickness 0.250in.
76 Skin thickness 0.190in.
77 Skin thickness 0.156in.
78 Upper skin 0.64in, lower skin 0.63in.
79 Passenger service panels (position variable with seat-pitch).

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is formed from a single girder no less than 5ft deep. The chief structural members in the floor are the transverse beams at each frame-station and the seat-rails, but the light-alloy upper panels are also reinforced by structural plastic top-hat longitudinals.

Pressure differential is at present about 8¾ lb/sq ft (see section on air-conditioning). All doors above the floor are outward-opening plug-type structures, fitted with double hinge-axes so that they can be pulled inwards and then slid out edgewise, special means being taken to reduce the depth to fit the frame during the opening or closing cycles. The cargo doors are mounted on tracked rollers and slide upwards and inwards. Windows contain three layers of Plexiglas or Gafite; the two pressure-bearing outer sheets form a sandwich with hot, dry air and the thin, floating inner lining has an anacoustic sound-absorbing function, although it can take full dP with a factor of 3. The windows are spaced at 40in intervals (alternate frames), and are of an unusual profile approaching the optimum form, the sides being arcs of large radius with a smaller radius in the corners. The major axis is vertical, the dimensions being 16in by 14in.

In order to prevent the large vertical tail from wagging the dog of a slim rear fuselage, the latter is built in one piece with the fin. The three fin spars are carried down into strong fuselage frames which, together with two intermediate frames, slope at the sweep angle of the fin. The profile of the rear fuselage has been so chosen as to prevent

Airliners of the World

DOUGLAS DC-8

DOUGLAS AIRCRAFT COMPANY, SANTA MONICA, CALIFORNIA

Douglas Model 1919 Over-water aircraft, powered by Rolls-Royce Conway engines

Drawn at Santa Monica in May-June, 1956.

DOUGLAS DC-8

Dimensions (all versions): span, 139ft 8¾in; length, 150ft 6in; height, 42ft 4¾in; gross wing area, 2,758 sq ft; track, 20ft 9¼in; distance between outboard nacelles, 90ft.

Model 1881. Domestic aircraft with four Pratt and Whitney JT3C turbojets of about 12,500 lb thrust.

Weights: Empty weight, 114,231 lb (wing, 26,922; fuselage, 19,651; tail, 4,737; undercarriage, 10,187; control surfaces, 1,768; nacelles, 3,256; powerplant total, 22,003; instruments, 605; hydraulics, 540; electrics, 2,647; pneumatics, 1,192; electronics, 1,621; furnishings, 15,652; air-conditioning and anti-icing, 3,328; and auxiliary gear, 122).

Capacity payload (space-limited), 34,280 lb or 122 passengers and 14,150 lb cargo; fuel capacity, 114,400 lb; operating weight empty, 119,726 lb; zero-fuel weight, 161,200 lb; design landing weight, 189,000 lb; usable take-off weight, 250,000 lb (design gross weight, 265,000 lb).

Performance: Field lengths (C.A.A., max. wt. at i.s.a.), 9,440ft take-off and 6,680ft landing; cruising speed at max. cruise thrust at 30,000ft at 220,000 lb (i.s.a.), 561 m.p.h.; range with 6,500ft field-length, 1,830 st. m.; maximum range with capacity payload, 3,550 st. m. using 16,500 lb reserve fuel.

Model 1910. Inter-continental aircraft with four Pratt and Whitney JT4A-3 or Rolls-Royce Conway RCo.10 engines.

Weights: Empty weight, 120,737 lb (JT4), 115,877 lb (Conway); operating weight, 128,862 lb (JT4), 123,726 lb (Conway); fuel capacity, 140,500 lb; capacity payload, 35,930 lb or 132 passengers and 14,150 lb cargo; zero-fuel weight, 167,550 lb (JT4), 163,750 lb (Conway); design landing weight, 190,500 lb; gross weight, 287,500 lb.

Performance: Take-off field lengths (C.A.A., max. wt., i.s.a.), 8,760ft (JT4), 9,000ft (Conway); landing, 6,690ft; cruising speed at max. cruising r.p.m. at 30,000ft at 220,000 lb, 586 m.p.h. (JT4), 582 m.p.h. (Conway); range from 6,500ft field, 3,060 st. m. (JT4), 3,280 st. m. (Conway); max. range with full payload, 4,470 st. m. (JT4), 4,810 st. m. (Conway).

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49 De-icing duct (cyclic heat).
50 De-icing trunk.
51 Hot-air anti-icing.
52 Production break.
53 Primary (combustion) airflow.
54 By-pass airflow.
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56 Intake to Sundstrand-drive oil-coolers.
57 Portion of flap (held up to clear jet blast).
58 Linkage to 57.
59 Lift spoilers (operated by nose-wheel-to-ground contact).
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61 Flap-operating linkage.
62 Main-leg sub-frame.
63 Main-leg retraction jack.
64 Tank-bay end-rib (full depth).
65 Un-notched ribs (not full depth).
66 Divided powered ailerons (inner = high speed, outer = low speed).
67 Bonded trailing-edge structure.
68 Aileron power unit (emergency manual tab).
69 Rudder power unit.
70 Tailplane hinge-axis.
71 Tank for injection-water (outers in tip, inners in centre section).
72 Fire-suppression bottles (378 cu in C.B. and Freon).
73 Leading-edge venting.
74 Air brakes under centre section.
75 Skin thickness 0.250in.
76 Skin thickness 0.190in.
77 Skin thickness 0.156in.
78 Upper skin 0.64in, lower skin 0.63in.
79 Passenger service panels (position variable with seat-pitch).

is formed from a single girder no less than 5ft deep. The chief structural members in the floor are the transverse beams at each frame-station and the seat-rails, but the light-alloy upper panels are also reinforced by structural plastic top-hat longitudinals.

Pressure differential is at present about 8¾ lb/sq ft (see section on air-conditioning). All doors above the floor are outward-opening plug-type structures, fitted with double hinge-axes so that they can be pulled inwards and then slid out edgewise, special means being taken to reduce the depth to fit the frame during the opening or closing cycles. The cargo doors are mounted on tracked rollers and slide upwards and inwards. Windows contain three layers of Plexiglas or Gafite; the two pressure-bearing outer sheets form a sandwich with hot, dry air and the thin, floating inner lining has an anacoustic sound-absorbing function, although it can take full dP with a factor of 3. The windows are spaced at 40in intervals (alternate frames), and are of an unusual profile approaching the optimum form, the sides being arcs of large radius with a smaller radius in the corners. The major axis is vertical, the dimensions being 16in by 14in.

In order to prevent the large vertical tail from wagging the dog of a slim rear fuselage, the latter is built in one piece with the fin. The three fin spars are carried down into strong fuselage frames which, together with two intermediate frames, slope at the sweep angle of the fin. The profile of the rear fuselage has been so chosen as to prevent

the occurrence of awkward shock waves near the tail surfaces by minimizing local airflow accelerations. The three strong frames picking up on the wing spars (stations 680, 781 and 857) involve forging round a portion of their periphery. The extreme nose is formed by a large dielectric moulding for the search radar.

A note should be added regarding noise. Overall sound-pressure level in cruising flight rises from 82 db at stations 300-500 to about 103 db at station 1,400. Of this, the major portion is due to shear and turbulence in the boundary layer over the fuselage; a passenger in the front of the cabin would not be able audibly to detect a complete shut-down of the engines. The fuselage trim layers are therefore unusually important, and include: Acoustimat (heavy foil); acoustic septum (heavy cloth) supporting glass-fibre sheets (unbonded); and honeycomb panels, which isolate vibration and also transmit heat from the incoming cabin air. The three-pane anacoustic windows equal the remainder of the structure in sound-proofing. Density of acoustic trim is under 0.3 lb/sq ft back to station 680, from which point it increases in stages to no less than 5½ lb/sq ft in the region of station 1,300, thereafter falling off rapidly.

Wing. The main evidence of fail-safe design is provided by the three spars, all of which have heavy sheet webs and modified T-booms. The centre and rear spar are parallel; the latter runs to the tip and carries the flaps and ailerons, whereas the former fades out into the front spar outboard of the outer engines. Each wing is made as a complete unit starting at the aircraft centre-line, where the port and starboard structures are bolted together. Well outboard on each half-wing is a manufacturing break which is intended to remain undisturbed after completion of the aircraft. Inboard of this break, the upper and lower skins between the front and rear spars are each one tremendous piece of roll-tapered light alloy with a thickness of a quarter-inch at the root. Massive forged straps reinforce the spar booms at the kink caused by the start of sweep at each wing root.

Roughly three-quarters of the wing loads are accommodated by the skin and underlying stringers. The latter are all extrusions, with profiles evolved by the N.A.C.A. Above the wing they have an attractive Y-form, structurally excellent and easily riveted to the skin and to brackets riveted to the relatively light ribs. The under-surface stringers are of modified I-section and are spaced closer than those on the upper surface, the latter being on approximately 6in centres. The ribs are liberally provided with large cut-outs (which act as tank baffles) and are separated from the skin by the depth of the stringers, with the exception of the tank end-ribs which run the full depth of the wing. The whole structure between the front and rear spars forms a large integral tank, and the exterior surface is carefully milled to an accurate profile. The leading and trailing sub-structures are quite secondary, all the fixed structure aft of the rear spar (apart from the main-gear attachments) being bonded.

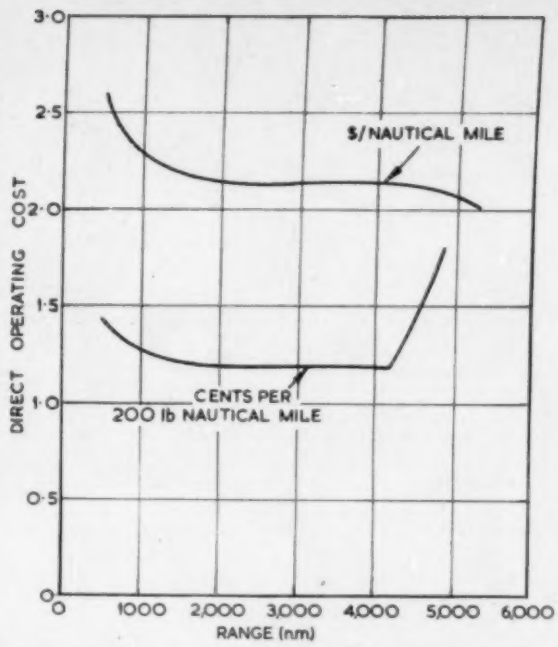
Leading-edge sweep is 30 deg, 5 deg less than in the original project. This modest value has reduced the weight of the wing and has permitted the use of relatively conventional ailerons, although it has necessitated the adoption of an unusual aerofoil of complex profile. The latter has been evolved by Douglas from N.A.C.A. sections of the 1930s, and the section changes progressively and radically from root to tip. At the root, the camber is negative and, quoting Dick Shevell, DC-8 aerodynamicist, "it keeps the local velocity down in parts of the airfoil . . . where this velocity would be critical, starting the drag rise"—meaning particularly that it postpones supersonic flow at the junction of the upper surface and fuselage. Douglas have treated wing and fuselage (and, for that matter, pods) as a lifting system and have designed them to match each other.

The suggestion of an "upside-down wing" fades out around the inner engines, the effective camber then being positive out to the tip. Effective wash-out of the camber line ensures that the stall starts at the wing root, and the aerofoil nose is relatively blunt to maintain maximum lift coefficient. Douglas believe that the wing increases the critical Mach number at a given lift coefficient, but it will have to fly at a rather greater angle of attack for a given lift than would a wing with all positive camber.

Tail. Both fin and tailplane have three principal spars. In the tailplane is the only extensive integrally stiffened primary structure in the whole airframe: the skin between the front and centre spars is formed from three machined planks. Each plank has three stiffening angles, and the two leading members are tapered off by the front spar. Most of the remaining skin in the empennage is stabilized by a bonded inner skin with stiffening flutes.

A remarkable feature is the extent of the structurally isolated top to the vertical tail surfaces, which are tuned for use as an aerial, with a central feeder cable. About eight feet from the tip the fin and rudder structures terminate completely. Structural glass-fibre sections are then inserted, extending over the entire chord of each surface and continuing up and down the rudder trailing edge (to achieve the required impedance pattern). The remainder of the (metal) structure is then bolted to the glass-fibre spars and around the profile periphery.

Pods. The engine pylons have two spars, chordwise frames and stringers. The spars pick up on stiff ribs in the wing which run fore and aft (unlike the majority of the ribs, which are perpendicular to the rear spar). Douglas have curved the trailing edges of the pylons inboard to follow the natural streamlines of the airflow; this gives lower drag than pylons used as fences which constrain the air to flow axially across the wing. The nacelles are conventional double-skinned assemblies made largely of titanium-alloy sheet; this material is not used elsewhere in the aircraft except for small details. A large access door (virtually half the nacelle) on each side hinges along the pod/pylon joint.



D.O.C. for 132-passenger Model 1910 with Conways: revised 1955 A.T.A. method with reserve for 260 n.m. at 30,000ft plus 1hr at 15,000ft (=16,800 lb), plus 3½ min. take-off thrust and 15 min. manœuvre.

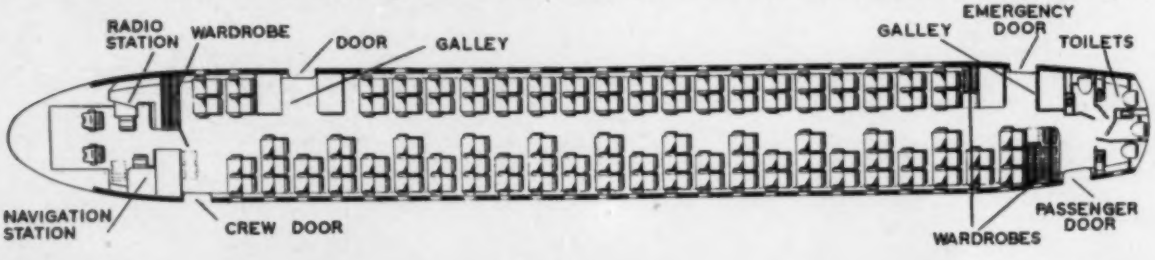
Undercarriage. Each main unit is carried by a large forging attached to the rear of the rear spar. Tests have shown that a complete leg can be torn away without rupturing the integral tanks and main wing structure. The forging lies in the fore-and-aft plane and is bolted to the rear spar and to a pair of sub-spars.

The track is 20ft 9½in. Each main leg is a forging, forked at the upper end and arranged to retract directly inwards. The main jack rotates a spanwise torque tube carrying what amounts to a radius strut incorporating a nutcracker (broken by an *ad hoc* jack), the small triangulation of the radius arm being the only steady pivot provided for the main leg. The arrangement is obviously strong in drift, but braking loads are reacted almost entirely by the shear loads of the widely forked main pivot. The trailing half of the bogie beam can be unlocked for taxying when the nosewheels have been steered through 40 deg, to reduce the minimum turning radius to 90ft. Dimpled tyres (Goodyear) at 131 lb/sq in and disc brakes are fitted, and the retracted units are stowed under the cabin floor in bays closed by multiple doors.

The nose leg is like an enlarged copy of that of the DC-7C, arranged for twin wheels. It is steered by two hydraulic cylinders (pedals, ±10 deg; wheel, ±60/74.5 deg) and retracts forward into an unpressurized box sealed by twin doors linked to the gear. All undercarriage units can be unlocked and allowed to fall under gravity and locked mechanically. A retractable tail skid is included, but studies of present operations may allow it to be deleted.

Flying Controls. For the first time on a transport aircraft, Douglas have fitted fully powered systems for the ailerons and rudder. The ailerons are split into inner and outer portions, the inners driving the outers at low airspeeds through a torsion-bar spring, so that all portions function in unison. Above a limiting i.a.s. the air-loads react against the spring to uncouple the outer sections. Should the power system fail on any surface, the aircraft can be flown *via* self-coupling manual circuits to the aerodynamic tabs without undue effort. The elevators are moved solely by the latter means and they are hinged to a variable-incidence trimming tailplane actuated by a hydraulic or electric motor (the latter is used for stand-by and autopilot drive) and two chain-driven screw-jacks with irreversible Acme threads.

Double-slotted, single-spar flaps of Douglas design are employed, the short inner portion on each wing being joined to the outer portions by multiple mechanical links. The general geometry is basically similar to that of the DC-7C, actuation being hydraulic (two rams on each outer flap and one on each inner section). A portion of flap in the line of each inner engine is hinged to a mechanical linkage so that it remains horizontal as the flaps come down and does not enter the jet stream. Under the belly are two large rectangular air brakes hinged just forward of the rear spar, each having its own hydraulic jack. They open in 6 sec and shut in 2 sec and blow back under air loads at speeds



Airliners of the World

DOUGLAS DC-8

in excess of cruising i.a.s. On the upper surface of each wing are mounted four small spoilers ahead of the flaps which are flicked open hydraulically—bussed together by cables—after touch-down, the circuit being energized by a micro-switch on the nose leg. Their purpose is to destroy lift and improve the traction of the wheel brakes.

POWERPLANT. The domestic Model 1881 is powered by the Pratt and Whitney JT3C-4 or -5 (described in the analysis of the previous aircraft) with a wet rating of from 12,500 to 13,000 lb thrust. Each engine is picked up by two semi-hoops suspended from the two spars of the nacelle pylon. Some 340 gal of water (without methanol) are carried for use during full-load take-offs at more than about 50 deg F. A 10-kVA drive is provided for a water pump for each engine, and the procedure will be to consume all the water in the first two minutes of flight so that none remains to freeze under cruising conditions. The water is carried in the wing tips and centre section.

Inter-continental DC-8s will be powered by the Pratt and Whitney JT4A-3 (commercial J75) or Rolls-Royce Conway RCo.10 by-pass engine; the Bristol Olympus 511 is also obviously suitable. Details of these engines are restricted, but their thrust will certainly lie in the range from 15,000 to 19,000 lb. Douglas believe that they are close to the optimum form of reverse-thrust, sound-suppressing propelling nozzle. Many systems have been investigated, and Douglas are assuming responsibility for evolution of the best arrangement. They have achieved 40-45 per cent reverse quite readily and have even recorded 58 per cent. The quiet nozzle and thrust-reverse portions are to be combined.

Accessories on the Pratt and Whitney engines are mounted beneath the high-pressure compressor casing. Two drum-type oil coolers are provided, each fed with air from an individual ram intake in the lower part of each nacelle. For the British engines fuel/oil heat exchangers will be employed, requiring no auxiliary intake. The complete nacelle will be isolated in the event of fire, and two-shot Freon systems are provided for fire suppression.

SYSTEMS. Air Conditioning. Cabin air is bled from the second (h-p.) spool of each engine at around 750 deg F and immediately cooled to about 400 deg F to reduce fire risk. At this temperature, the air is fed to a battery of four Douglas air turbines (maximum, 55,000 r.p.m.) in the nose, where they drive compressors feeding fresh air to the cabin. The dP is 8.67-8.73 lb/sq in (6,700ft at 40,000ft) and any one turbo-compressor can maintain it. Behind the nose-under-carriage bay is a closed-circuit Freon refrigeration system supplied by the Carrier Corporation. It is energized by two tiny supersonic rotors and provides 26-ton refrigeration.

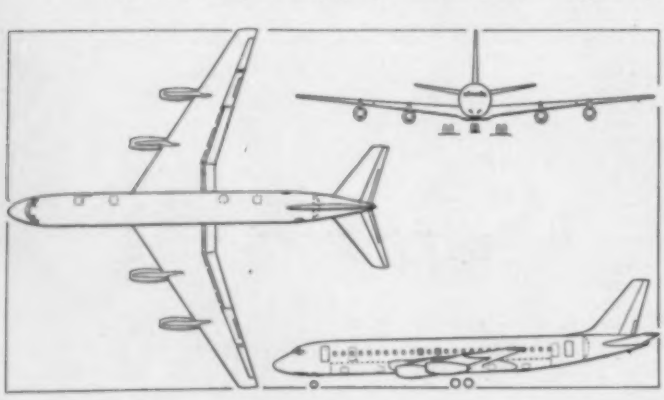
Warm air is fed to trunks in the cabin roof, and down multiple ducts in the sides of the fuselage from which it escapes into the honeycomb-filled cabin wall, which consequently acts as a source of radiant heat. The air finally enters the cabin beneath the baggage racks. All the overboard spill from the cabin and air turbines is ejected through a propelling nozzle on the ventral centre-line which Douglas consider to be worth 4 m.p.h. in cruising flight.

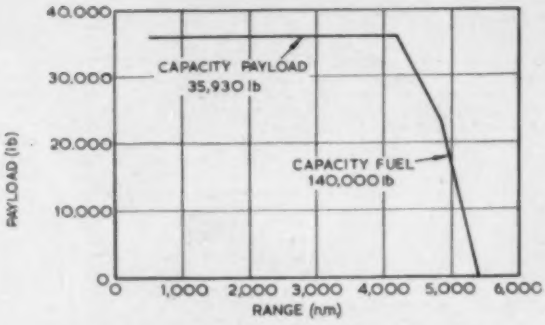
Fuel. As already noted, the entire wing between the front and rear spars forms an integral tank terminated at the inner end by the centre-line of the aircraft on the inter-continental DC-8, and by an end-rib on domestic versions. The outer end-rib is spaced about three from the wing tip (station 727). The manufacturing joint in each wing divides the capacity into what are termed main and auxiliary tanks on each side. Total capacity is 14,650 gal (17,999 gal in Model 1910).

Each engine has its own tank system, with cross-feed to the remainder. Feed from the immersed boosters is backed up by further line boosters driven by the engines. Immersed pumps feed to a fuel box (a species of header) on each powerplant, and Douglas are guaranteeing a very modest quantity of maximum unusable fuel, without reliance on accessory power. Under-wing sockets are provided, through which the system can be pressure-fuelled in 16 minutes.

Hydraulics. The inboard engines each drive a multi-plunger variable-stroke pump energizing the hydraulic system to 3,000 lb/sq in. Choice of variable-stroke pumps reduces surge and fatigue problems and saves about 12 per cent power in allowing the full design pressure to be utilized. An electrically driven stand-by pump is provided, with its own reservoir. The "system compartment" is accessible from a main bogie bay.

Services supplied include the landing gear, flaps, spoilers, speed brakes, wheel brakes, nosewheel steering, engine-starting air compressor, tailplane trim and aileron and rudder power. Douglas co-operated with Monsanto Chemicals in the evolution of Skydrol 500 which will be standardized; it is a development of the well-known non-flam fluid used on the DC-7, capable of operation down to −100 deg F.





Payload/range curve for Model 1910 at 287,500 lb.

Electrics. All electrical power is generated at 115/208 V, three-phase, 400 c.p.s. by 20 (or 30) kVA alternators on each engine with Sundstrand hydraulic drives. The system, for which Jack and Heintz are responsible, has a heavy overload capacity, is fully paralleled and completely automatic in isolating defective portions of circuit, and is also "modularized" for easy maintenance. Transformer-rectifier sets, rated at 25 amp, supply small quantities of D.C. current to certain instruments and electronic services. No storage batteries are associated with the system at any point.

Ice Protection. All aerodynamic surfaces, together with the nacelle pylons, are de-iced by hot air bled from the engines. The double-skin leading edges are fed with air from multiple-branch manifolds which exhaust into a curved diaphragm behind each leading edge. The air then escapes into the space forward of the front spar on each surface, and thence to atmosphere. The engine and air-conditioning intakes and the radome are protected by the same basic system.

Intense heat is applied for short periods on a cyclic basis, this being considered preferable to continuous (anti-icing) heating in preventing ice from re-forming further back on the surface concerned. (The intakes of the engines are an exception in that they are continuously anti-iced.) The entire span of the wing and tail surfaces is treated from root to tip. At no point is there a pipe temperature in excess of 400 deg F.

FLIGHT EQUIPMENT. Normal operating crew comprises captain, first officer and engineer (who, having virtually no powerplant duties, is a "systems manager"), with a seat for a supernumerary observer; in addition provision is made for a navigator on over-water DC-8s. If required the aircraft can be flown by a crew of two. Cockpit glazing comprises multi-layer panels (Nesa glass, Vinyl, thick glass, air-space, thick glass, Vinyl and Nesa glass, in that order), two of the largest opening to provide direct vision. Rain is cleared by air jets supplied from the air-conditioning bay in the nose.

Among the very full radio equipment is search radar, housed in a heated nose radome. Aerials are generally suppressed, the fin incorporating V.O.R. windows in structural dielectric and the whole upper part of the vertical tail being isolated to form an aerial of the correct impedence and radiation pattern. Standard equipment includes duplicated h.f. and v.h.f. communication, duplicated A.D.F. and glide-slope, marker beacon, Loran, radar transponder and "Hi-range" radio altimeter, together with flight interphone and p.a. system.

PAYLOAD ACCOMMODATION. The total usable length of passenger cabin is approximately 97ft; interior floor-width is 130in and height from floor to ceiling about 95in at the centre-line (100.5in to the outer skin). Within this space the following features facilitate a wide variety of interior layouts; seats and partitions mounted on standard rails; readily changeable reading lights and cold-air outlets; passenger and service doors and emergency exits at both ends; removable berths integrated with the baggage racks; buffets at both ends; radiant heat and conditioned air outlets distributed along the whole usable length; and rest rooms, or lounges, at both ends. The arrangements shown in the large drawing and the floor plan are typical. Another configuration which has found favour is to use alternate twin and triple seats, to allow cabin staff to pass easily. Such an arrangement provides for 100 passengers; in all-six-abreast seating a total of 131 can be carried.

The two large freight holds under the floor have a combined capacity of 1,415 cu ft. The door arrangement has already been described. It is intended that luggage and freight off-loading shall be capable within six minutes, the overall turn-around time being 30 min.

COMMERCIAL HISTORY. Douglas were already deeply engaged in work on the Model 1881 long before its existence was announced one year ago. The first order was that of Pan American, who bought 25 in October 1955 for £57m; this order was subsequently revised to read: Pan American, 21 for delivery starting in December 1959, and Panagra, 4 (with JT4A engine) for delivery from early 1960. Subsequent orders have been as follows:—

United, October 1955, 15 with JT4 and 15 with JT3 (for subsequent re-engining) for delivery from May 1959 at £62.5m; National, November 1955, 8 with JT3 from mid-1959 at £13.2m; K.L.M., November 1955, 8 with JT4A (option on further 4) from early 1960 at over £18m with spares; Eastern, December 1955, 6 with JT3 from May 1959 and 12 with JT4 from March 1960 (option on another 8 with JT4 from autumn 1961) at a total (with option) of £59m with spares; Japan Air Lines, December 1955, 4 with JT4A from first half of 1960 at £9.8m; S.A.S., December 1955, 7 with JT4A from 1960 at £18m; Swissair, January 1956, 2 with JT4A from spring 1960 at £5.83m; Delta, February 1956, 6 with JT3 from June 1, 1959, at £12.9m; and T.C.A., May 1956, 4 with Rolls-Royce Conway from early 1960 at £7.88m, with an option on 2 more.

Airliners of the World

VISCOUNT

VICKERS-ARMSTRONGS (AIRCRAFT), LTD., WEYBRIDGE SURREY

NO other airliner of recent years has started so completely from nothing and gone on to equal or surpass the impact on the world's affairs of all other transports. It is the first example in history of a British "mainliner" reaching the top rung of the ladder and being bought or sought after in all parts of the world.

Originally, the basic V.C.2 design was much smaller than the present Viscount; at its genesis in 1945 the weight was around 30,000 lb. Early history—outlined at length in our issue of July 15, 1955—was far from sure, and in the summer of 1948 the Viscount seemed to be doomed. At this point, however, there began a process of increasing the power of the Rolls-Royce Dart turboprop and stretching and increasing the weight of the airframe, and this not only saved the Viscount, but has ensured that it will be built by the hundred.

The first production machines were delivered at 56,000 lb and fitted for ten rows of four seats or, as in B.E.A. service, for some triple seats, raising the capacity to 47/53. Engines were Dart 505s at the RDa.3 rating of 1,400 s.h.p. (1,547 e.h.p.). Since 1954, aircraft of this size have been delivered with the Dart 506 giving greater cruise power, and the certificated weight has climbed through 57,000 lb and 58,500 lb until most of the current production is cleared at 60,000 lb with the Dart 510 of 1,780 e.h.p., and the latest aircraft—such as the T.A.A. V.756 with slipper tanks—can operate at 63,000 lb.

During 1952 B.E.A. ordered the first of a new family of "Viscount Majors" designated V.801 with a fuselage length increased by 13ft 3in. Subsequently, it was decided that a better proposition would be to reduce the "stretch" to 46in (all ahead of the wing) but to move back the rear pressure bulkhead 65in, giving 111in of extra usable length. The first batch of such aircraft, designated V.802, are now coming through the factory at Hurn with Dart 510 powerplants and a weight of 62,000 lb.

From this aircraft has stemmed a whole family of heavier, more powerful Viscounts which are admirably fitted to keep the design in the front rank during the coming decade. As an intermediate step, B.E.A. have bought the V.806 with Dart 520s of RDa.7/1 rating of 2,100 e.h.p. (de-rated to 1,990 e.h.p.). From this aircraft has stemmed the V.810/840 which is described in detail in the succeeding pages.

The chief changes introduced by these machines are: installation of Dart 520s in various ratings in stronger nacelles to allow for the later installation of the Dart RDa.8 (with the same take-off power-limit, but with considerably higher cruising power), to give the V.840; strengthened rib and spar structure and heavier-gauge skin in the inner wings to allow for increased i.a.s. and greater weight; stronger undercarriage and brakes with higher energy-absorption; reinforced rear fuselage to accept higher tail loads; a stronger tail to permit operations at higher airspeeds and to accommodate greater asymmetric engine-failure loads; and horn-balanced elevators and rudder for more powerful control.

When the RDa.8 is installed, the Viscount will fly substantially faster and higher than at present, and engine power is such that there is plenty in hand for good field-performance, water/methanol being required only in extreme cases. With these aircraft a cruising speed of 400 m.p.h. will be possible, with a miles-per-gallon figure approximately the same as that of the earliest Viscounts operating 10 tons lighter and 100 m.p.h. slower. Such performance has already been widely investigated with the V.700 prototype in which some of the engineering changes of the V.810/840 are now on test. The underlying aim in the development of these new Viscounts has been to incorporate all the lessons learned in past operations in every part of the world, while retaining the basic simplicity inherent in the design.

AIRFRAME. Although the general form of the Viscount is almost ten years old, Vickers-Armstrongs are well satisfied that the structure of the V.810 will be completely adequate for arduous and highly competitive operations in the future. During the past four years, particularly as a result of sales in Canada and the U.S.A., the basic design has been subjected to considerable detail refinement, and all this experience is making the V.810 a very well-known quantity. As already described, the new aircraft are strengthened to increase the structural i.a.s. limit by some 50 kt with a weight penalty of approximately 900 lb.

Fuselage. Construction is generally conventional with open channel frames notched to receive angle stringers to which the skin is flush-riveted. The complete hull is built as one unit between the pressure bulkheads, the dP being 6.5 lb/sq in. The cockpit roof is a large convex pressing riveted to the periphery of a cut-out in the surrounding structure of the pressure hull and faired over by secondary skin. From station 24 (behind the radome and pressure bulkhead) to 824.85 (near the rear pressure dome) the floor is flat and level, the overall load intensity being 100 lb/sq ft, with 150 acceptable in certain areas. At station 460 is a strong frame aligning with the main wing-spar, the leading- and trailing-edge spar frames being at 403.826 and 501.234.

Frame spacing is irregular; it is generally of the order of 22in, but can fall to 12 or exceed 27in. Main passenger windows, of which there are

Airliners of the World

VISCOUNT

Vickers-Armstrongs V.810 Viscount in typical "American" form

Drawn at Weybridge in June, 1956

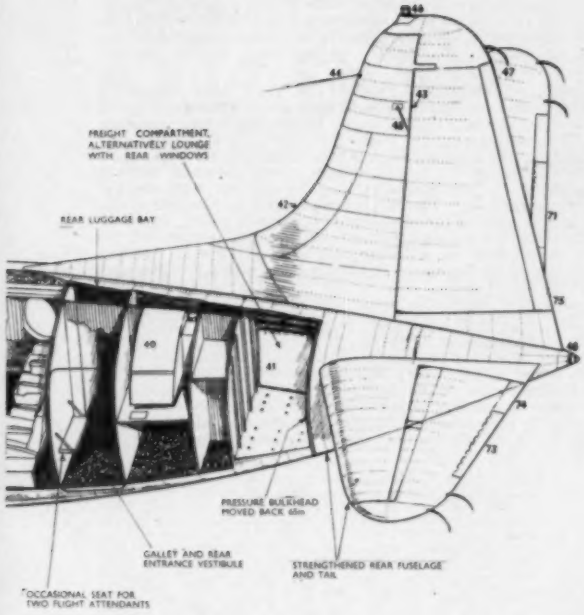
"FOUR-ENGINE" FUEL SYSTEM. 20 FLEXIBLE CELLS FORMING FOUR TANKS TOTAL CAPACITY 1,916 Imp gal
TWO-MAN FLIGHT-CREW WITH OCCASIONAL THIRD SEAT
TOILETS—PORT AND STARBOARD
SEATS FOR 52 PASSENGERS
EMERGENCY EXITS, 7 WINDOWS, 4 STARBOARD SIDE AND 3 PORT SIDE
WEATHER RADAR BENEATH HEATED RADOME
PASSENGERS' "CARRY-ON" LUGGAGE BAY
46in ADDED TO FUSELAGE
AIR-CONDITIONING BAY
STRENGTHENED WING STRUCTURE TO ALLOW FOR OPERATION AT 67,500 lb
WATER-METHANOL TANK BAY 55 Imp gal EACH SIDE
RECTANGULAR ENTRANCE DOOR WITH FOLDING STAIRWAY
DOUBLE-SLOTTED FLAPS
UNDERFLOOR (PRESSURIZED) FREIGHT HOLD (TWO DOORS 5'9"D)
STRENGTHENED UNDERCARRIAGE AND BRAKES WITH HIGHER ENERGY ABSORPTION
ROLLS-ROYCE DART 520 (Rda.7) TURBOPROP OF 2,550 h.p.
JOHN PALMER

1 Warm air to cockpit.
2 Single static vent to safety devices.
3 Pitot head.
4 Windscreen de-icing fluid pressure connection.
5 Nesa glass heated windscreens.
6 Triple windscreen wipers and alcohol spray-bars.
7 Direct-vision panels.
8 Cockpit pressure dome.
9 Unpressurized fairing.
10 Windscreen de-icing fluid tank.
11 Icing inspection lamp.
12 V.H.F. (No. 1) aerial.
13 V.H.F. (No. 2) aerial.
14 Nosewheel steering wheel
15 Aerotherm pilots' seats.
16 Rudder-pedal units with toe-brakes.
17 Bendix PB.10A autopilot motor group.
18 Main radio crate (remainder in underfloor freight hold).
19 Cockpit door.
20 Nosewheel steering cylinders.
21 Towing point (scissor-link released).
22 Crew fixed oxygen.
23 Hydraulic cupboard.
24 Non-flushing type toilets.
25 Ship's library.
26 Public address (Bendix).
27 Duplicated A.D.F. aerials (Marconi 7092C).
28 Ice-guard.
29 Passengers' service panel under light luggage rack.
30 Sliding curtains (no sunblinds).
31 Chair-back tables.
32 Emergency exit external release.
33 Flap motor and gearbox.
34 Flap torque tube and driving chains.
35 Flap guide rails and radius arms.
36 Aileron control pressure-seal.
37 Aileron control run.
38 Intercooler airflow (flush intake).
39 Conditioned-air duct.
40 Galley equipment.
41 Baggage bay door.
42 Double-skinned leading edge of wing, fin and tailplane.
43 De-icing air outlets.
44 H.F/Loran aerial (for ferry only).
45 V.O.R. and I.L.S. localizer aerials.
46 "Pounder"-type anti-collision beacon.
47 Static dischargers.
48 Navigation lights.
49 Tank-bay linings perforated for rubber retaining studs.
50 Bag-type fuel tanks.
51 Airflow through oil cooler.
52 Electric de-icing pads.
53 Firewall and fire access panels.
54 Fire-suppression bottle; three spray rings in nacelle.
55 Rotol accessory gearbox on each engine driving Godfrey cabin blowers (three only), generators, hydraulic pumps and airscrew de-icing alternators.
56 Cabin blower delivery duct (intake on nacelle inner flank).
57 Main engine mounting point.
58 Vickers 14in-stroke undercarriage. Dunlop tyres, wheels, steel-disc brakes with Maxaret.
59 Retraction jack.
60 Retraction bay and door linkage.
61 Jet-pipes.
62 Tank-access panels.
63 Pacitor gauge covers.
64 Float-switch covers.
65 Gravity-filling points (pressure refuelling below wing).
66 Landing lamp.
67 Access to outer-plane attachment bolts.
68 Irving-balanced split ailerons, skew-bar operated.
69 Nine ribs only in each wing, plus light chordwise members.
70 Outer cowling petal with hinged top section; inner carries lower cowling.
71 Trim tabs.
72 Balance tab.
73 Anti-balance tab.
74 Spring/servo tab.
75 Servo/trim tab.

26 (or 30 with a rear lounge) are ellipses measuring 26in × 19in, with the major axis vertical. Six windows above the wing are emergency exits, together with another window forward to starboard. All are separated by two or more frames, and additional vertical stiffeners are attached to the skin to act as tear-stoppers. Earlier Viscounts had elliptical doors (structurally correct, but expensive and wider than necessary); Viscount Majors have basically rectangular doors with rounded corners. Most V.810-type aircraft have a main door 60in × 36in on the port side of the forward fuselage with the optional incorporation of a power-folding stairway. On each side of the rear fuselage are doors measuring 66in × 27in capable of use as entrances, exits or emergency exits (B.E.A. V.802s and the 806s have a large rectangular door at the front for carrying bulky freight above the floor). If the rear of the fuselage is used as a baggage hold, a door 36in × 30in is provided to starboard.

Beneath the floor is a large pressurized and heated hold between station 132 (behind the unpressurized nosewheel bay) to 381.75 just ahead of the wing. Access is gained via two doors to starboard, each about 30in high by 42in. Ruling width of the floor is 104in. Quick-release panels provide access to the batteries, electric and hydraulic services (stations 423-445), the flap motor and gearbox (541-563), to the tail unit at the extreme rear and, through the hinged radome, to the weather radar.

Wing. The section is a modification of N.A.C.A. 63, the thickness/chord ratio being 15.5 per cent (root) to 13 (tip). Structurally there are five portions comprising inner planes bolted to a carry-through structure in the fuselage, outer planes extending from just beyond the


FREIGHT COMPARTMENT, ALTERNATIVELY LOUNGE WITH REAR WINDOWS
REAR LUGGAGE BAY
PRESSURE BULKHEAD MOVED BACK 65in
GALLEY AND REAR ENTRANCE VESTIBULE
STRENGTHENED REAR FUSELAGE AND TAIL
OCCASIONAL SEAT FOR TWO FLIGHT ATTENDANTS

VICKERS-ARMSTRONGS V.810 VISCOUNT
Four Rolls-Royce Dart 526-series turboprops

Dimensions: span, 94ft; length, 85ft 7in; height, 26ft 9in; track (oleo centres), 23ft 10in; wheelbase, 28ft 8.6in; wing area, 963 sq ft (gross), 834 sq ft (nett); flaps, 76.75 sq ft per side; ailerons, 47.4 sq ft each, aft of hinge; horizontal tail, 238 sq ft gross; vertical tail, 124 sq ft; fuselage overall diameter, 128.1in.

Weights: empty weight, 39,890 lb (structure, 18,311; powerplant total, 7,950; fixed and removable equipment, 10,650); crew, 660 lb; flight equipment, 22 lb; oil, 154 lb; payload (including 1,890 gal fuel), 26,774 lb; maximum weight, 67,500 lb.

Performance (estimated) with assumptions as listed on p. 10: take-off field length, 5,600ft at 65,000 lb; climb (14,000 r.p.m. at 60,000 lb), 1,900 ft/min at sea level; cruising (at 60,000 lb at 14,000 r.p.m.), 299 kt (344 m.p.h.) at 26,000ft at 0.119 n.a.m./lb and 315 kt (363 m.p.h.) at 18,000ft at 0.098 n.a.m./lb; landing field length, 3,150ft at 55,000 lb (2,420ft using anti-skid).

Approximate figures for V.840 (RDa.8 engines): dimensions, as above; weights, as above, except powerplant group, 8,322 lb (raising empty weight to 40,500 lb) and payload 27,664 lb, the take-off weight being 69,000 lb; performance: field lengths, at least as good as V.810; cruise (60,000 lb at 14,200 r.p.m.), 334 kt (384 m.p.h.) at 30,000ft at 0.122 n.a.m./lb; 348 kt (400 m.p.h.) at 23,000ft at 0.102 n.a.m./lb.

centre-line of the outer engines, and detachable tips.

Main bending loads are taken by a single spar at 40 per cent chord. Vickers are confidently adhering to this arrangement, knowing that it works satisfactorily and, unlike more complex structures, can be evaluated with assurance. The bottom boom, or tension flange/cap, is designed to the low lg level of 10,000 lb/sq in, in L.65 (equivalent to the American 14-ST6). In the port inner nacelle this boom carries a transmitter for a strain range counter provided as standard equipment. Subsidiary forward webs lie at 5 and 70 per cent chord, and the torsion box is completed by light peripheral chordwise channel-members at 8in spacing, and nine complete plate ribs in each wing; there are no spanwise stringers.

Skinning is in large sheets continuous round the leading edge from beneath the leading-edge spar to the top edge of the trailing member. Plate joints are butt-strapped with double rivet rows through doubler plates overlying the chordwise channels. Outboard from the inner nacelles a double leading-edge skin forms a duct for hot de-icing air. Each main-spar root is attached to the fuselage bridge-piece by 12 taper bolts, and four more locate the roots of the leading and trailing webs. Access to the bag tankage is gained through doors in the under-surface.

Tail. Both the fin and the fixed-incidence tailplane employ a single spar at the trailing edge, multiple pressed ribs and a double-skin leading edge for thermal de-icing. The tailplane is attached to the fuselage frames by two bolts on the spar and one at the leading edge, and bolted fillets act as torque and drag members. Control surfaces are hung on four hinges inset between double ribs and supported on box cantilevers from the rear of the fixed surface.

Undercarriage. All three legs comprise single Vickers oleos carrying twin wheels and retracting forwards by single hydraulic jacks into unpressurized bays fitted with pre-closed doors. The main wheels and hydraulic disc brakes with anti-skid equipment are by Dunlop or Goodyear, the tyres being of 36in diameter inflated to 111 lb/sq in. The nose unit is steered by twin hydraulic cylinders.

Flying Controls. All tail control surfaces are manually operated by spring tabs actuated by push-pull rods and provided with spigot locks (for 80-kt gusts), permitting one engine at a time to be run to full power. In previous Viscounts, the rudder and elevators were sealed by a beak and fabric strip, the hinges being inset to give 40 per cent balance. In the V.810, considerably greater rudder power is required with increased angles of deflection, particularly in sideslips and to hold asymmetric conditions; increased elevator power is likewise needed to maintain the existing c.g. range with the more powerful engines. As a result, hinge moments at large angles have been reduced by cutting the balance to 25 per cent and providing horn-balances to make up the difference. The leading edge of each movable surface is smooth and blunt and separated from the fixed surface by a gap set at $\frac{1}{4}$in with the controls centralized (on the elevator this allows snow to fall through), the gap decreasing to zero at full deflection.

Conventional ailerons are employed, operated not by spring tabs but directly through skew bars. A balance tab is fitted to port and a trim tab to starboard. Each aileron retains Irving-type balance, with a beak and fabric pressure-seal.

Double-slotted flaps are fitted in three portions on each wing. Each section is built up on an H-spar and top-hat formers; the end-ribs are castings which transmit the drive and also carry the slats. All portions are moved by an electric motor in the fuselage (with manual emergency) driving through torque tubes and multiple endless chains. The latter pull the sections out on steel rails while tie-rods pull the flaps down to a maximum angle of 47 deg. The latter is optimum for landing; in a baulked landing, the flaps are automatically taken off to 40 deg by opening the throttles.

POWERPLANT. Each engine is a basically identical Rolls-Royce Dart 520 turboprop rated to RDa.7/1 standard. This specifies 2,100 e.h.p., but in the V.810 the engines are power-limited to 1,800 s.h.p. (1,990 e.h.p.), giving a reserve of power up to i.s.a.+6 deg C, above which water/methanol is employed.

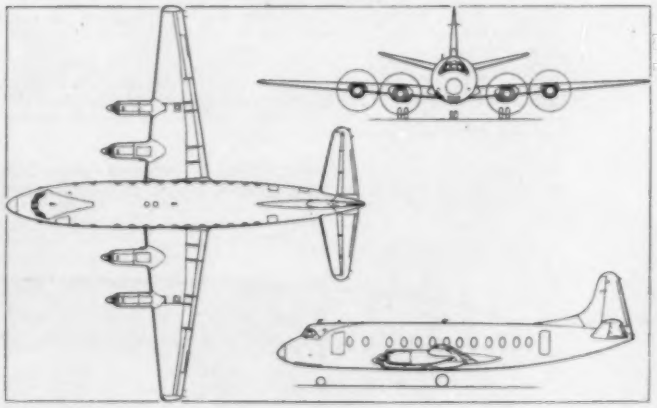
Originally, the V.701s and their successors (Dart 505) cruised at 13,300 r.p.m. (290 m.p.h.), but were later cleared at 13,600 r.p.m. (780 e.h.p. at 23,000ft), giving 302 m.p.h. true. In a similar manner, the Dart 520 is to start life on B.E.A.'s V.806s at 13,400 cruising r.p.m.; after about one year, the recommended r.p.m. will be raised to 14,000, giving the performance shown in the accompanying data and curves.

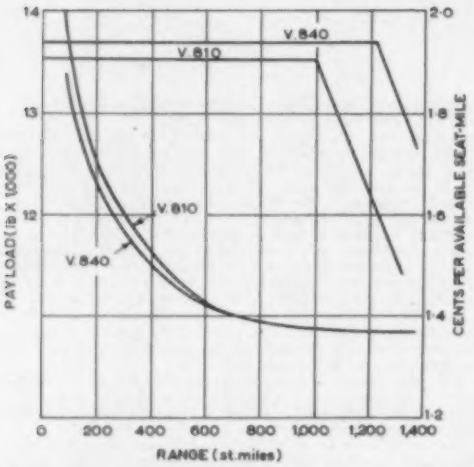
Dart 520s differ from earlier engines in several respects, chief of which are the introduction of three shrouded stages of turbine blades and automatic top-temperature control. The engine was described in our issue dated May 11, 1956. A typical cruising power will be 1,325 e.h.p. at 20,000ft with a specific consumption of 0.57. The later RDa.8 will introduce, *inter alia*, a shrouded compressor providing a theoretical power of 2,500 e.h.p.; when de-rated to the Viscount limit of 1,800 s.h.p. (in this case giving 2,080 e.h.p.) full take-off power will be available up to i.s.a.+27 deg C. A typical cruise power will be 1,740 e.h.p. at 20,000ft at 14,200 r.p.m. with a specific consumption of 0.54; this will be available in the spring of 1959, and a still more efficient engine, cruising at 1,840 e.h.p., should be in service in the spring of 1961.

All Viscounts are driven by four-blade airscrews made by Rotol or de Havilland, embodying auto-feathering or pitch-coarsening, and ground-fine pitch for starting and braking; auto-synchronization is standard. Owing to the 1,800 s.h.p. power limit, the airscrews for the new Viscounts may be very similar to the constant-chord (paddle) units used on current Dart-510 aircraft; nevertheless, Vickers are investigating a higher-activity airscrew which, for a slight cruise penalty, will greatly increase performance from short fields.

The method of installation is quite clear from the cut-away drawing, steel-tubular mounts being used with a structurally separate petal-type cowling and an intake and nose cowl attached to the engine. Starting is electric. Oil is carried in an integral tank around the intake with a capacity of 25 pints, and a cylindrical air/oil heat exchanger is mounted in a separate duct in the upper part of the cowling. Water/methanol is carried in a 55-gal bag in each wing immediately outboard of each inner nacelle, and is fed by S.P.E. electric booster pumps. A Rotol accessory gearbox is mounted in the top of each nacelle

This three-view drawing shows the Viscount V.810 as at present conceived. The RDa.8-powered V.840 will be virtually identical.





Viscount cost-curves based on the Lockheed method slightly modified to suit the British aircraft. Such a method has been found to work extremely well in studying actual operations of earlier Viscounts.

Airliners of the World

VISCOUNT

immediately behind the firewall. Engine control is by a single lever and later V.810-type aircraft will have an automatic fuel-datum to compensate for varying ambient temperature.

SYSTEMS. Air Conditioning. All but the port outer accessory gearboxes drive blowers which supercharge the cabin at a rate of 75 lb/min at 25,000ft, the design pressure being 6.5 lb/sq in. The basic system is a conventional arrangement of silencers, inter-coolers and cold-air units (air-cycle turbines), but heaters and Freon refrigeration can be installed if required.

Past Viscount experience is manifest in the cabin-air system of the V.810. In current Viscounts the air enters the cabin from skirting louvres and leaves along a roof duct; this is likely to be reversed in the new aircraft, air being introduced beneath the baggage racks and extracted at foot level.

Fuel. For a considerable time, Viscounts have used a "four-tank" system. Total capacity is 1,890 gal contained in flexible bags comprising 20 inter-connected cells on both sides of the main spar outboard of the wing root. Each tank has a gravity filler, and the whole system can be pressure-fuelled or de-fuelled from a 200 gal/min socket at head-height in each outer nacelle.

Equipment in American V.810s includes duplicated Thompson booster pumps, Pacitron contents gauges and Bendix flowmeters. Compressor-bleed air is used for fuel heating. Provision is also made for fitting a 145-gal slipper tank outboard of each outer engine—an optional addition long used by T.A.A. V.720s—and for fuel-jettison under the pressure of the tank booster pumps.

Hydraulics. Each inner gearbox drives a Lockheed Mk 9 pump energizing the system to 2,000/2,500 lb/sq in. Services include undercarriage operation and nosewheel steering, and a separate circuit energizes the wheel brakes. An emergency hand-pump is provided adjacent to the reservoir in the forward fuselage.

Electrics. All four accessory gearboxes drive a D.C. generator feeding to a regulated line voltage of 28. Three (or four) Varley lightweight accumulators are installed and the distribution system is conventional. Among the electrical loads are flap operation, engine starting and the windscreen wipers. Each gearbox also carries a small non-paralleled alternator supplying resistive de-icing loads. Supplies of alternating current for the instruments and heated windscreen panels are taken from the main power system via two 115-V inverters under the floor.

Ice Protection. Exhaust gas from each inner jet-pipe can be passed through a heat exchanger in the nacelle. Ram air from separate intakes inboard of these nacelles is heated and ducted to the double-skin leading edges of the wings (outboard of the inner engines), fin and tailplane. The air divides at the centre of each leading edge and flows chordwise, finally escaping from flush louvres in the skin.

The engine intakes are anti-iced by Dunlop electric elements, and a similar form of protection is provided for the airscrews. The horn balances are heated by Napier Spraymats drawing current from the small alternators. Windscreens are protected by fluid sprays and wipers and/or by Nesa or Triplex conducting glass.

Flight Equipment. In American service, provision is made for a flight crew of two, but a third crew-member can be accommodated if required. Standard flight equipment varies according to the operator. The usual autopilot is almost certain to be the Smiths S.E.P.2 or Bendix PB.10A. As an example of radio equipment, Continental's V.812s will have very full equipment by Collins, Bendix and Marconi, and a Murphy public-address system. If required, weather radar can be installed beneath the hinged nose radome.

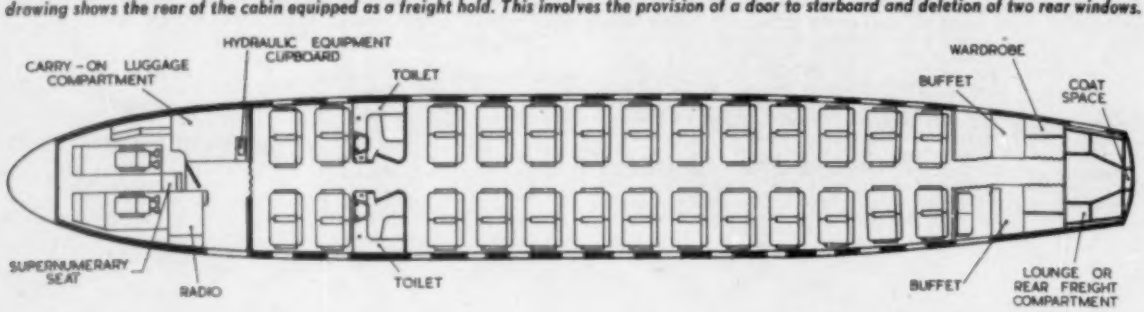
PAYLOAD ACCOMMODATION. The floor plan shown is typical; in this form, exceptionally large seats are fitted four-abreast at 37in pitch with a central aisle 23in wide. The seating can be varied up to a total of at least 70.

By redesigning the interior, the V.810 is effectively 4in wider than are current Viscounts; the trim has been moved outwards without sacrificing sound- or heat-insulation, and the cold-air ducts are re-located beneath the floor. Two toilets are provided in the plane of the airscrews and, in spite of the considerable increase in power, the noise level is likely to be lower than in present aircraft. Usable cabin volume (excluding toilets) is of the order of 2,620 cu ft, or 2,500 cu ft if the rear lounge is used for baggage. The under-floor hold is 19ft long and has a capacity of 270 cu ft.

COMMERCIAL HISTORY. First deliveries were made to B.E.A. in early 1953. Production was moved from Weybridge to Hurn in that year and is now proceeding at the rate of about 80 aircraft annually at both locations. Over 120 have been delivered, and orders now being placed are priced at about £350,000 for delivery in 1958. The first Viscount Majors are B.E.A. V.802s, due to enter service in October; the V.806 with Dart 520s will be in service next year and the V.810 the year following (1958), with conversion to 840 standard scheduled for 1959. The following is an alphabetical list of Viscount contracts so far announced (the total is 327):—

Aer Lingus: 4 V.707 (Dart 505), Nov. 1951, delivery completed April 1954, 53-seat interior, Dart 506 engine fitted later; 3 V.808 (510), March 1956. *Air Austria:* 4 V.803 (510), Jan. 1956, equipment as specified by K.L.M. *Air France:* 12 V.708 (505), Nov. 1951, delivery completed August 1954, 48-seat interior, Mk 506 engines fitted later. *Broathens S.A.F.E.:* 1 V.742 (510), Sept. 1954. *British European Airways:* 20 V.701 (505), Aug. 1950, delivery completed March 1954, Mk 506 engines fitted later, 47-seat interior; 6 V.701 (505), Aug. 1952, delivery completed July 1955, Mk 506 engines fitted later, 47-seat interior; 1 V.701 (506), May 1955, ordered as Elizabethan replacement; 12 V.802 (510), Feb. 1953; 10 V.802 (510), May 1955; 2 V.802 (510), Jan. 1956 (the last three orders are first of 800-series, with fuselage extension of 46in; provision for 44-70 seats); 14 V.806 (520), Jan. 1956, first Viscount with Dart 520, not convertible to RDa.8-powered 400 m.p.h. version; also option, May 1956, on 7 V.810 and 12 V.840). *British Overseas Airways Corporation:* 8 V.754 (510), June 1955, for use by B.O.A.C. associates (eastern routes); 4 V.772 (506), June 1955, for use by B.O.A.C. associates (western routes). *British West Indian Airways:* 3 V.702 (506), June 1953, delivery completed Nov. 1955, 44/53-seat interior; 1 V.702 (506), April 1954. *Butler Air Transport:* 2 V.747 (506), June 1954, first aircraft delivered Sept. 1955. *Canadian Department of Transport:* 1 V.737 (506), April 1954, for government use, airframe as for T.C.A. but with V.I.P. interior. *Capital Airlines:* 3 V.744 (506), June 1954, delivery completed July 1955, 40-seat interior; 37 V.745 (510), Aug. 1954; 20 V.745 (510), Dec. 1954 (first nine aircraft delivered with Mk 506 engines for subsequent conversion) 40-seat interior; V.811. *Central African Airways:* 5 V.748 (510), July 1954, de Havilland airscrews. *Compania Cubana de Aviacion:* 3 V.755 (510), aircraft originally ordered by Airwork and sold to Cubana; 3 V.810 (520), June 1956. *Continental Air Lines:* 12 V.812 (520), Dec. 1955, first of 810-series, with cruising speed of 365 m.p.h., due for re-engining in 1959 with RDa.8, giving speed of 400 m.p.h. and converting aircraft into Viscount 840; 3 V.812 (520), Feb. 1956; 5 V.812 (520), June 1956. *Fred Olsen Airtransport:* 2 V.736 (506), Jan. 1954, completed in Dec. 1955, leased to B.E.A. for two years; 1 V.766 (510), June 1955; V.779 (re-order); 3 V.805 (510), Sept. 1955. *Hong Kong Airways:* 1 V.760 (510), Oct. 1954; 1 V.760 (510), Feb. 1955, fitted with slipper tanks, assigned to B.O.A.C. Jan. 1956. *Hughes Tool Company:* 1 V.763 (510), June 1955, normal airline interior, ordered "for study and analysis of turboprop aircraft". *Hunting Clan Air Transport:* 3 V.732 (506), May 1953, delivery completed July 1955, aircraft subsequently leased to Middle East Airlines; 2 V.759 (510), Nov. 1954. *Indian Air Force:* 1 V.723 (506), Nov. 1953, luxury interior, delivered Dec. 1955; 1 V.730 (506), Nov. 1953, V.I.P. interior for presidential use, delivered Jan. 1956. *Indian Airlines Corporation:* 5 V.768 (510), July 1955. *Iraqi Airways:* 3 V.735 (510), July 1953, delivery completed Dec. 1955; 1 V.773 (510), March 1956. *Iranian Government:* 3 V.782 (510), March 1956, two for Persian air services, one for personal use of Shah. *K.L.M.:* 9 V.803 (510), June 1955, 52-seat mixed-class interior. *L.A.I.:* 6 V.785 (510), May 1956. *Linea Aeropostal Venezolana:* 3 V.749 (506), May 1954, basically similar to Capital version. *Lufthansa:* 7 V.814 (520), June 1956; also option on nine. *Misrair:* 3 V.739 (506), March 1954, delivery completed Jan. 1956. *New Zealand National Airways Corporation:* 3 V.807 (510), Nov. 1955. *Pakistan International Airways:* 3 V.815 (520), May 1956, to be re-engined later with RDa.8. *Pakistan Government:* 1 V.734 (510), March 1955, V.I.P. interior, for presidential use, delivered April 1956. *Philippine Air Lines:* 2 V.784 (510), April 1956. *South African Airways:* 7 V.813 (520), March 1956. *S.A.A.F.:* 1 V.781 (510), April 1956, V.I.P. interior. *Standard Oil Company:* 1 V.765 (510), June 1955, custom-built executive interior. *Transair:* 2 V.804 (510), June 1955. *Trans-Australia Airlines:* 6 V.720 (505/6), June 1952, delivery completed April 1955, two aircraft with Mk 506 engines and slipper tanks, earlier aircraft re-engined with Mk 506; 1 V.720 (506), April 1955, replacement for first T.A.A. Viscount, lost in training accident; 3 V.756 (510), April 1955; 2 V.756 (510), Sept. 1955 (certificated at 63,000 lb), deliveries proceeding; 2 V.816 (520), April 1956. *Trans-Canada Air Lines:* 15 V.724 (506), Nov. 1952, first North American Viscount, delivery completed Feb. 1956; 7 V.757 (506), Aug. 1954; 3 V.757 (506), April 1955; 11 V.757 (506), Sept. 1955. *Union of Burma Airways:* 3 V.761 (510), May 1955. *United States Steel Corp.:* 3 V.764 (510), June 1955, custom-built executive interior.

This interior layout is virtually that ordered by such operators as Continental. There are other "standard" configurations and the cut-away drawing shows the rear of the cabin equipped as a freight hold. This involves the provision of a door to starboard and deletion of two rear windows.



Airliners of the World

BRITANNIA

BRISTOL AIRCRAFT, LTD., FILTON, BRISTOL

BASICALLY the design philosophy of the Britannia is stated by the manufacturers in the following terms: "It is the application of a sophisticated structure with good aerodynamic qualities to take the best advantage of the operational characteristics of the high power free-turbine turboprop engine. The advantages of speed, range, negligible vibration and low noise level that the large turboprop possesses *vis-a-vis* the piston engine introduces a manifold advance over the classic piston-engined airliners that it was natural to pursue, and the design of an aircraft to exploit these advantages to as advanced a degree as was considered practicably possible was thus undertaken. Operational requirements were established in conjunction with B.O.A.C. and the resulting synthesis defined the basic characteristics of the aircraft that we now know as the Britannia.

"Whilst it is true to say that in almost every particular the Britannia broke new ground, it was, nevertheless, entirely natural that some degree of conservation should be exercised in the creation of the initial design in terms of the extent of future developments. Having established authoritative data by physical experience with the introductory aircraft the way ahead to various developed versions of the basic type could explicitly be seen. The first variant in this "stretching" process was given the designation Series 300 (the first production Britannia Series is designated 100) and the basic difference was to increase the fuselage length by 10ft 3in and to employ later versions of the Proteus engine, of higher power. The Britannia 100 is powered with four Bristol Proteus free-turbine turboprops of 3,900 e.h.p.; the later model Proteus —the 755—produces 4,120 e.h.p.

"Shortly after the conception of the Series 300, increasing attention on the part of a number of international airlines in advancing long-range operation—and particularly the grail of all-weather, non-stop North Atlantic operations—led to the design variation of a long-range version of the Series 300, this initially being designated 300 LR but subsequently having its own Series number of 310. Again, the only fundamental difference between the 300 and 310 is that the latter is equipped with increased fuel tankage where the longer range is obtained.

"A further variant was conceived as an adjunct to the Series 300: this was designated Series 250 and it differs from the 300 only in the provision of a strengthened floor in the front fuselage to permit the carriage of heavy bulk loads in a freight compartment between the passenger cabin and the flight deck. With the advent of the LR version of the 300, however, it was only natural to extend the extra tankage scheme to the 250 as well. This was done and the standard Series 250 Britannia now has the same range ability as the Series 310.

"These are the basic forms of the Britannia as they exist up to date. There are naturally further variations planned—for example to take advantage of the considerable increases in almost every department of performance that the new Bristol turboprop—the two-spool supercharged B.E.25 Orion—makes possible. It is, however, too early to be definitive at this stage in discussing these planned developments: suffice it to say that these conceived, but as yet unborn, members of the Britannia family will proffer considerable advances in payload, range, speed and operational economy. [See page 71.]

"One of the primary relevant factors is that the advent of the gas turbine sounded the death knell of the piston engine as an aircraft prime mover for all except the smaller and lighter categories of aircraft. Obviously the knell has been and will continue to be a long time a'ringing, but this in no way affects the validity of the basic premise.

"Unfortunately, however, the gas turbine in its most simple and directly applied form—i.e., the turbojet—has an inherently high fuel consumption by comparison with that of the piston engine. And by the same token, whilst the jet engine is an effective means of propulsion it is a less efficient means of propulsion than is the airscrew up to speeds of the order of 500/550 m.p.h. There was thus a patently obvious case for investigating the possibility of wedding the airscrew to the gas turbine so as to take advantage of the power producing method and characteristics of the gas turbine whilst at the same time maintaining the airscrew's high propulsive efficiency. The result is the type of engine known as the turboprop.

"The attack made on this problem at Bristol, however, produced a unique result in that concentration was focused on the creation of an engine in which the compressor and turbine (power-producing) system is mechanically independent of the airscrew/turbine system. This design feature is fundamentally important to the Britannia case because it confers a degree of operational flexibility, particularly in terms of flight altitude, that is unapproached by any other turbine-powered aircraft. It is also responsible for the unusually low specific fuel consumption.

"The combination of a highly efficient power installation and a large capacity airframe of markedly low structure weight has resulted in an aircraft which offers to airlines a means of carrying greatly increased payloads over very much longer ranges at very much higher cruising speeds than is possible by any other existing aircraft and moreover offers this ability with the profound attraction of so low a level of operating cost as wholly to change the complexion of revenue production.

All in all, therefore, the place of the large turboprop airliner would seem to be assured not only in its own right as a highly efficient and economical transport vehicle of great work capacity, but also for complementing the large jet airliners on the many routes for which they are explicitly unsuitable. There are indeed cogent grounds for belief that the large turboprop airliner will be the most widely used type of aircraft on the major air routes of the world over the next fifteen years."

AIRFRAME. A measure of the structural efficiency achieved in the Britannia is the fact that structure weight is barely one quarter of gross weight, despite the low nominal stress level and the heavy fatigue-resistant properties of the design.

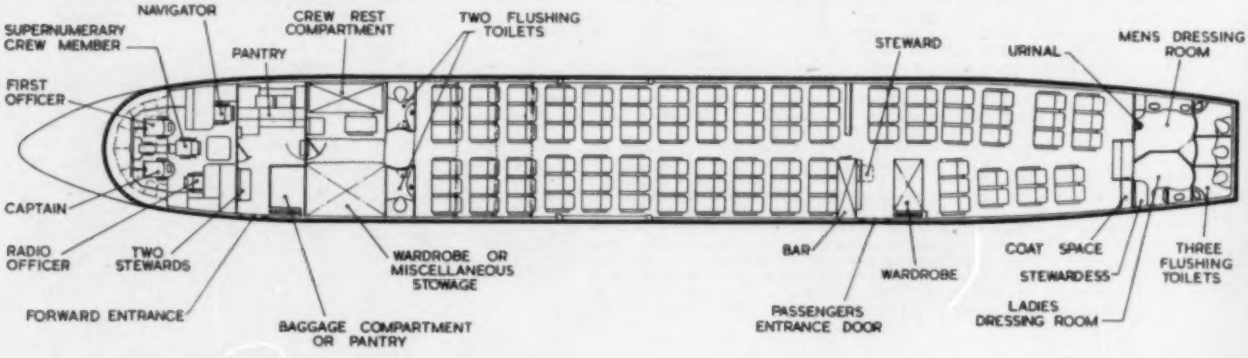
The basic airframe material is high-strength light alloy. The 12ft diameter fuselage is stressed for a differential cabin pressure of 8.3 lb/sq in, and general skin thickness is 18-gauge. The fuselage is of constant circular section for 49ft 2½in of its 124ft 3in overall length (this is a 10ft 3in increase on the early Britannia 100), and there are no bulkheads or other structural intrusions anywhere in the usable part of the fuselage. The floor is carried on longitudinal beams, and is designed for an overall loading of 75 lb/sq ft between the wings and the toilets, and 37 lb/sq ft elsewhere. The two under-floor freight-holds are stressed to 75 lb/sq ft.

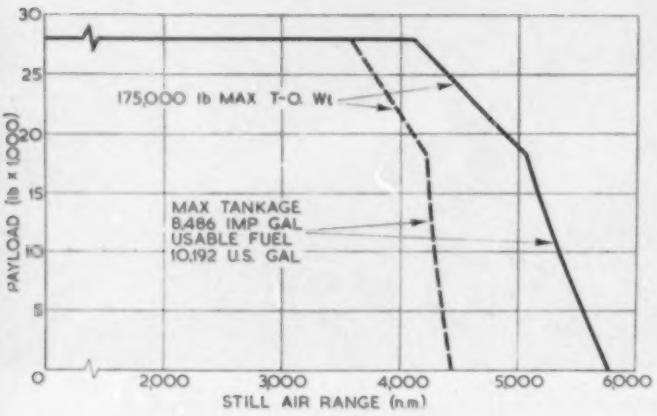
There are four emergency exit doors at the aft end of the cabin, including the main entry door, plus two jettisonable window-hatches in the cabin over the wing. The windows comprise two separate glazings which can be removed independently, and both of which are capable of standing full pressure.

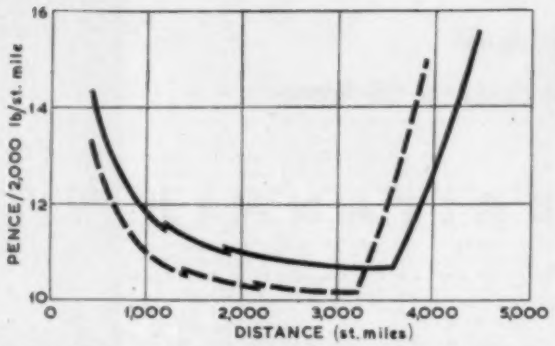
A heavy programme of static and fatigue-testing involving five separate fuselage specimens has been carried out by Bristol and at the R.A.E., Farnborough.

The wing has a taper box-spar bounded by webs at 15 and 50 per cent chord. Bending loads are taken by upper and lower skins and spanwise stringers. Overall skin thickness is 0.16in; general stress levels are low and special attention has been paid to detail design from the point of view of fatigue. The interspar box provides the maximum possible space for fuel.

The flaps are in four sections, and are disposed between the inner nacelles and the fuselage and between the inner nacelles and the ailerons. Each flap-section is double-slotted and is extended on curved







In both these curves (above and left) the full lines are for long-range cruise at 300 kt t.a.s. and the broken lines for high-speed cruise at 248 kt c.a.s.

Airliners of the World

BRITANNIA

steel tracks by screw-jacks (driven in unison through torque tubes from an electric actuator). Ailerons are of conventional construction, and hinged freely to the wing (see Flying Controls).

Undercarriage is of British Messier design and manufacture. The main legs each carry a four-wheel bogie, the rear wheels of which have rather greater track than the front pair. Tyre pressure is 139 lb/sq in, and wheels, tyres, brakes and anti-skid units are by Dunlop. The bogie retracts into a nacelle bay covered by three pairs of doors; upon retraction the bogie-beam pivots about a lateral axis until it is in line with the leg, whereupon the entire unit retracts rearwards, the bogie being finally stowed in an inverted position. The nose undercarriage has twin wheels splined to a live axle, and is steerable hydraulically through a range of 50 deg on either side of neutral; the unit retracts forwards.

POWERPLANT. The Britannia has four Bristol Proteus 755 turboprops of 4,120 e.h.p. each (B.O.A.C.'s Britannia 102s have Proteus 705s rated at 3,900 e.h.p.) driving de Havilland four-blade 16ft hollow-steel-blade airscrews. The cowling has, in effect, three skins; the entire engine is enclosed within a double-walled cowling, between the skins of which passes the intake air, while the innermost skin is a light unstressed fairing clipped to the engine itself. The top cowling panel is located between a pair of fixed longitudinal beams and can be lifted off after releasing its fasteners. The remainder of the cowling is formed by two large panels, port and starboard, which hinge upwards to provide unobstructed access to the engine and oil cooler. Exhaust gas passes through a stainless-steel jet pipe running back across the top of the wing, to which it is attached by two pairs of pivoted links; the jet exhausts from a propelling nozzle above the trailing edge. The jet pipe shroud is of titanium, as also are other appropriate hot portions of the installation. The engine is slung from four twin mountings around a ring in line with the centrifugal compressor. Each engine has a reverse-flow axial compressor followed by a centrifugal impeller.

The airscrews are advanced units of de Havilland design and manufacture, incorporating the well-known Hamilton Hydromatic principle of operation. They are fully feathering and reversing, and incorporate the D.H. hydraulic pitch lock, a safety device which locks the blades at the angle at which they are operating in the event of any failure in the hydraulic control system. Phase and r.p.m. synchronization equipment are standard. A super-fine ground pitch-setting permits the engines to be opened up to high r.p.m. on the ground for running the generators.

The Bristol B.E.25 Orion turboprop, which develops some 75 per cent more cruising power, will be available for retrospective installation in 1960. (B.O.A.C. have ordered 60 for this purpose.)

SYSTEMS. Flying Controls. The primary controls of the Britannia are not in any sense power operated; the basic principle of operation takes the form of aerodynamic servo tabs operated directly from the cockpit. Each surface carries full-span tab-sections on its trailing edge and is freely hinged to the airframe so that, in flight, each main surface takes up a position according to the aerodynamic load on its tab. Control movements are transmitted from the flight deck through gearboxes and high-speed torque tubes. Because stick force is the sum of internal control-circuit friction and tab hinge-moment, neither of which is sufficient to provide reasonable feel, artificial feel is provided for ailerons and rudder, and for the elevators feel proportional to airspeed is provided by a Hobson feel-simulator into which is fed stick-displacement and q information. Elevator trim is effected by the innermost of each elevator's four tabs, this tab being in fact reserved for trimming. All four rudder tabs are connected to the normal control system, but each aileron has five tabs, of which the innermost is actuated by a separate circuit interconnected with the rudder circuit. This results, when rudder is applied, in roll due to dihedral in yawed flight while retaining optimum dihedral for level flight. This makes it possible to make small corrections to heading by applying rudder, which with conventional controls would cause yaw with sideslip.

Special provision for control-locking is made; this is achieved by small hydraulic jacks, it being impossible when they are applied to open the throttles all at once above flight-idling power (one engine on each side can however be opened up to full power). Autopilot is the Smiths S.E.P.2.

Cabin Air. Air is tapped from the centrifugal (h-p.) impeller of each Proteus engine, its temperature being reduced by ram-air heat exchangers. The circuit includes a Godfrey cold air turbine-expansion unit for further cooling. The maximum differential cabin pressure is 8.3 lb/sq in (6,000ft at 35,000ft), and two engines are capable of maintaining this pressure. At the latter altitude the fuselage is ventilated with 120 lb of conditioned air per minute, distributed from ceiling ducts. Air is taken away from the cabin through floor-level grilles and filters to jet pumps, which induce a re-circulation flow of 150 lb per minute. Air from the toilets, freight holds and pantry is dumped directly overboard. Normalair and Teddington Controls equipment ensure, respectively, automatic pressure and temperature control.

Electrics. Auxiliary power is supplied by four 50 kVA Rotax alternators, one driven by each engine. Carbon-pile voltage-regulation is used in the main system, magnetic amplifiers being employed to control inverter frequency and voltage. Six 24-volt, 25 amp-hr lead-acid batteries comprise the storage capacity, and they are capable of supplying essential loads for 20 min in the event of complete generation failure; they can also provide two engine starts. Full electrical load can be maintained by any three alternators, and essential services, plus some domestic load, can be maintained by only two.

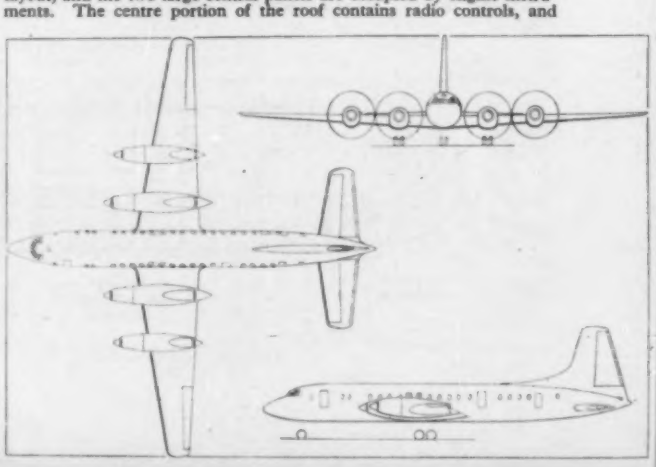
Hydraulics. The Britannia's four hydraulic pumps are electrically driven; they are British Messier units, and are installed in the unpressurized portion of the fuselage. Pressure is maintained at 3,500 to 4,000 lb/sq in, and the hydraulic system powers undercarriage retraction, control-surface locking, and nosewheel steering. Wheel brakes take 1,750 lb/sq in; elevator artificial feel and control damping is a separate circuit. Accumulators maintain pressure for towing and parking purposes, and an independent pump supplies pressure for emergency undercarriage lowering. A separate electro-hydraulic system operates the Dunlop windscreen wipers.

Fuel. All fuel is housed within the box spar of the wing. Capacity is made up of bag tanks (7,566 Imp. gal total) and integral tanks in the outboard wings (920 Imp. gal total). Total fuel capacity is thus 8,486 Imp. gal. Feed is by a pair of submerged booster pumps in each of the four main tanks; the low-pressure feed from each tank to its adjacent engine is independent of the others except for cross-feed, and any engine can be fed from any tank. Unusable fuel is less than 50 gal, and all but 1,600 gal can be jettisoned. The whole system is suitable for kerosine or JP-4, and heaters (using compressor air) are provided at the engine filters. Pressure refuelling at 150 gal/min is effected through connectors in the outer nacelles.

Ice Protection. There are two major systems: hot air and electric mats. The former utilizes hot gas tapped from between the compressor- and power-turbines of each engine, diluted with air induced from the flow inside the cowling. This mixture is used to heat the leading edge and outer walls of the main cowling and intakes, together with the elbow to the compressor intake and the radial intake vanes. Pre-selected temperature control is automatic. Protection of the wings is also achieved by hot air from the same source.

The complete empennage is protected by Napier Spraymats applied to the leading edges of the tailplane and fin, and on the double-curvature surfaces of the elevator horn balances. They are applied also to the ventilating air intakes in the two upper fixed beams in each engine cowling. Airscrew blades and spinners are heated by internal electric elements. The six forward windscreen panels are also electrically heated by a transparent conducting layer on the outer glass lamination.

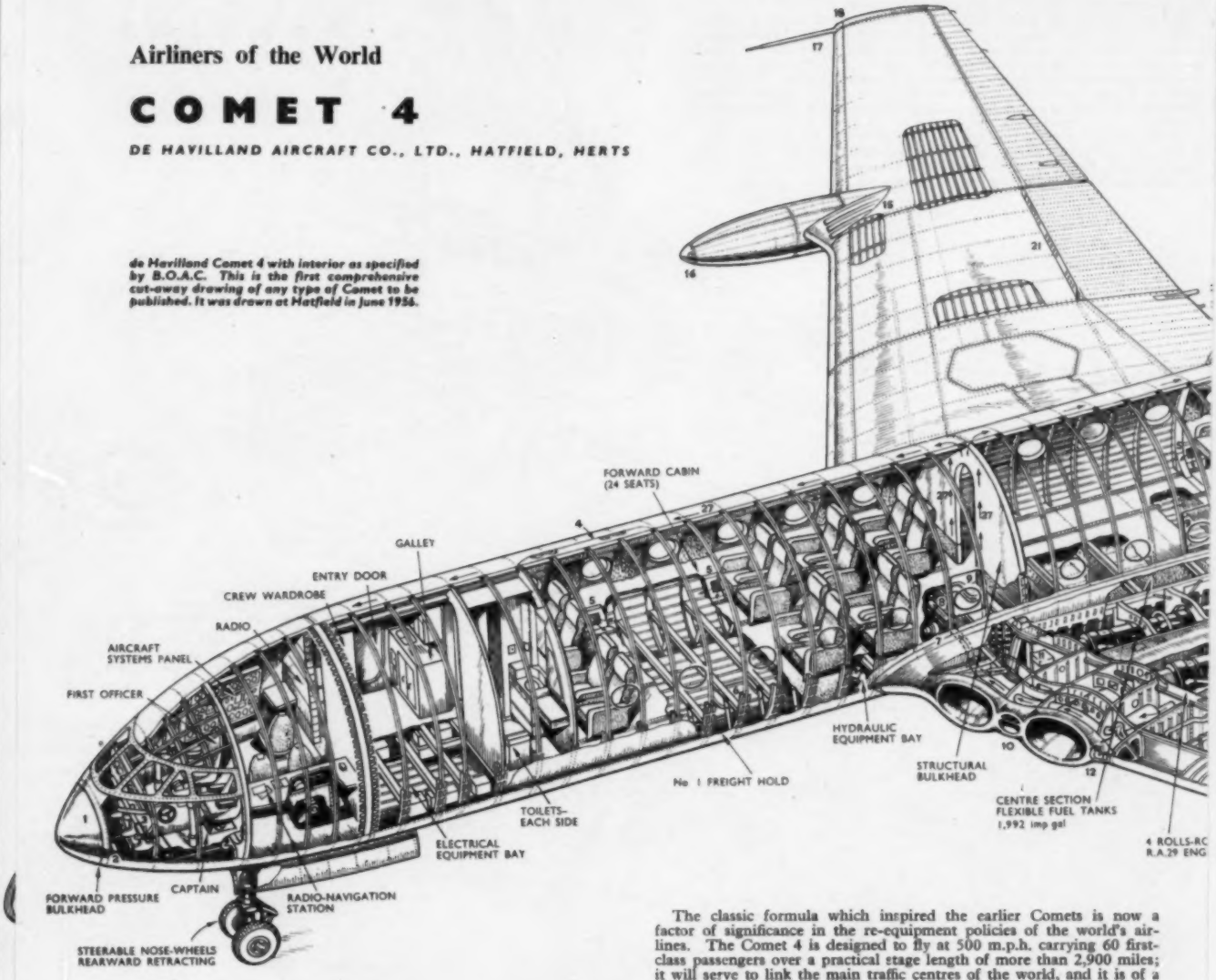
FLIGHT DECK. Provision is made for two pilots, navigator and radio officer, with a supernumerary seat available for a fifth crew member. All essential instruments and controls can be reached by either pilot. The Smiths flight director system is fitted as standard, employing no more than two panel instruments—director horizon and beam compass. Each pilot's flight instrument panel conforms to the standard accepted layout, and the two large central panels are occupied by engine instruments. The centre portion of the roof contains radio controls, and



Airliners of the World

COMET 4

DE HAVILLAND AIRCRAFT CO., LTD., HATFIELD, HERTS



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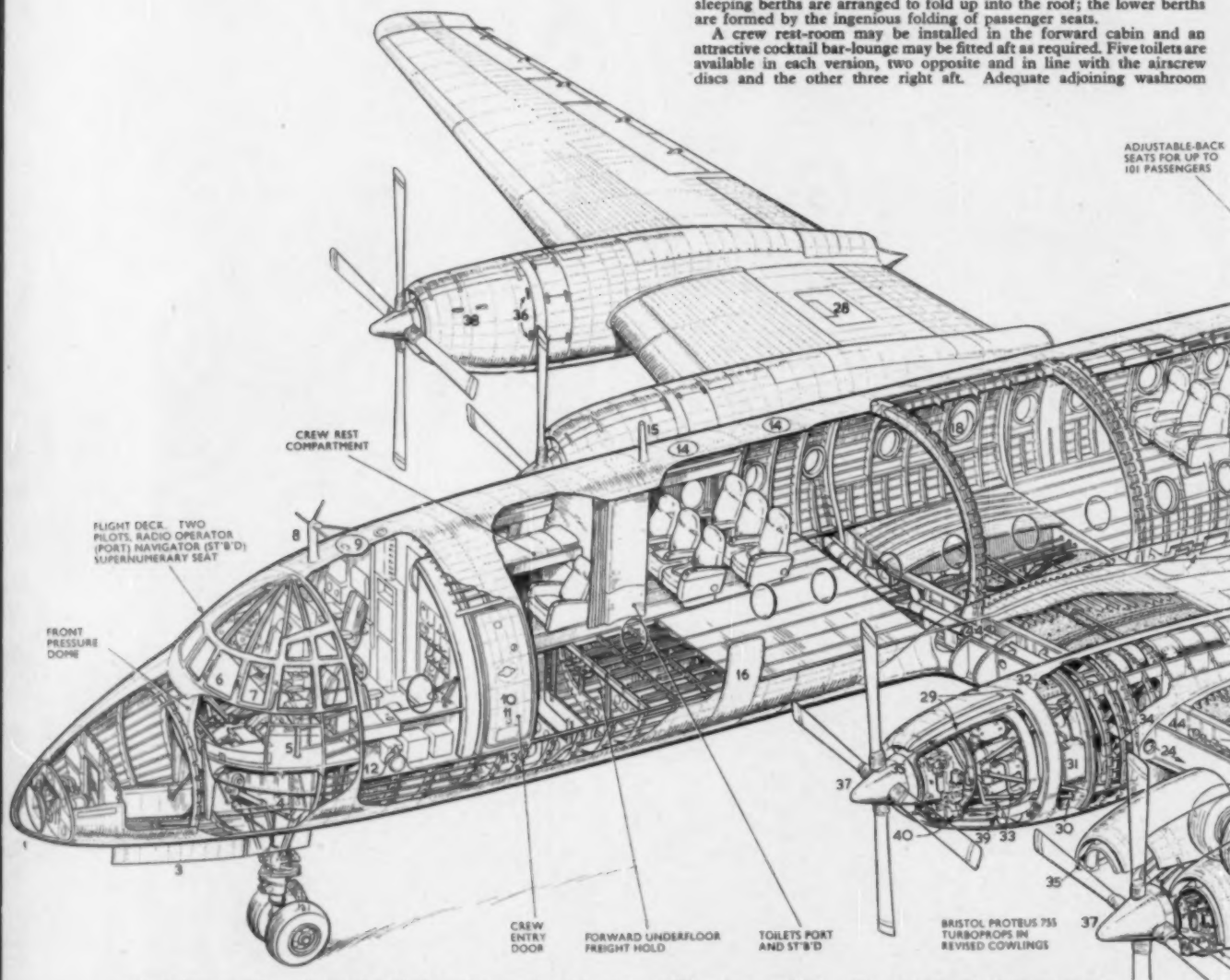
BRITANNIA

slots are at 1in pitch to permit rapid changes of seating accommodation either four, five or six abreast. Movable partitions further permit variation of accommodation, and are designed to be installed quickly. Six-abreast seating for 93 passengers forms the standard version of the Britannia; this may be compared with the luxury first-class sleeper version, suitable for transatlantic non-stop services, which seats 64, including 17 single-width upper berths and 15 double-width lower berths with four fully reclining "sleeperette" chairs. The 17 upper sleeping berths are arranged to fold up into the roof; the lower berths are formed by the ingenious folding of passenger seats.

A crew rest-room may be installed in the forward cabin and an attractive cocktail bar-lounge may be fitted aft as required. Five toilets are available in each version, two opposite and in line with the airscrew discs and the other three right aft. Adequate adjoining washroom


ADJUSTABLE-BACK SEATS FOR UP TO 101 PASSENGERS
CREW REST COMPARTMENT
FLIGHT DECK. TWO PILOTS, RADIO OPERATOR (PORT) NAVIGATOR (ST'B'D) SUPERNUMERARY SEAT
FRONT PRESSURE DOME
CREW ENTRY DOOR
FORWARD UNDERFLOOR FREIGHT HOLD
TOILETS PORT AND ST'B'D
BRISTOL PROTEUS 755 TURBOPROPS IN REVISED COWLINGS

roof windows on either side are of particular assistance when flying in the circuit.

The "systems" control panels are worthy of special note: the fuel panel, for example, is virtually a diagrammatic picture of the fuel system. All fuel lines are indicated, warning lights are in their correct relative positions and flow meters take the place of the engines. Similar panels are employed for other systems.

The navigator has a large chart table and access to the roof sextant, and all crew members are provided with generous stowage space for documents, personal effects, and so forth. Crew sleeping-berths (two bunks) may be fitted as required on the starboard side immediately aft of the flight deck.

Radio and Radar. A typical installation is as follows: duplicated H.F. transmitter-receivers; twin V.H.F. transmitter-receivers; twin A.D.F. receivers; I.L.S.; D.M.E. (200 Mc/s); duplicated V.O.R.; Loran; search radar; intercom and public address systems.

Wherever possible, all aerials are suppressed. The forward part of the fin tip is the Loran receiver and the H.F. aerials are suppressed in each wing-root leading edge. Twin A.D.F. suppressed loops are submerged in the fuselage upper skin and the search radar is contained beneath the radome in the unpressurized portion of the nose. The latter part of the aircraft also carries V.O.R./D.M.E. homing aerials on either side and a D.M.E. distance aerial below.

PAYLOAD ACCOMMODATION. The Britannia's cabin is 99ft long and 12ft wide, and the entire length is unobstructed, with a headroom of 6ft 8in. Seat attachments are provided by two sets of twin slotted-rails set at the international standard track of 31.7in, and these facilities are provided. The 76-seat mixed-class arrangement allows for 60 tourist-class passengers in the main cabin and 16 first-class seats in the aft cabin, including the cocktail lounge. A spacious pantry is situated behind the flight deck.

Two underfloor freight holds, one forward of the wing (386 cu ft), the other aft (443 cu ft), are accessible *via* large (30in by 51in) freight doors under the starboard side. Both freight holds are pressurized, and their floors stressed to 75 lb/sq ft.

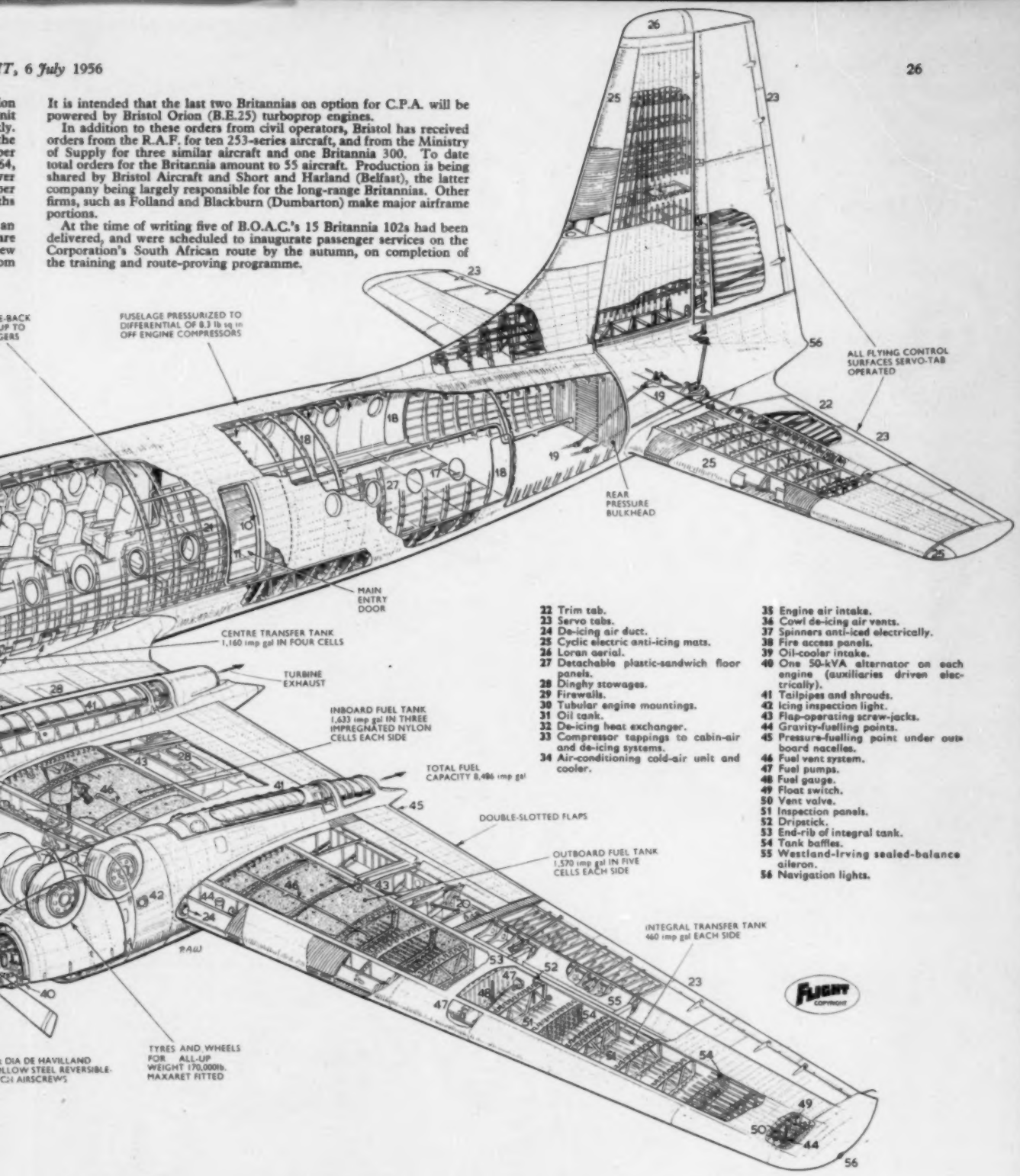
COMMERCIAL HISTORY. The first order for the Britannia was placed by B.O.A.C. in July 1949, for 25 aircraft. The first six of these were to have had Bristol Centaurus piston engines, but in December 1950 this idea was abandoned, and it was decided that all the aircraft should be powered by the Bristol Proteus turboprop. In August 1955 B.O.A.C. increased their order from 25 to 33 aircraft, made up as follows: 15 Britannia 102s, eight Britannia 302s, and ten Britannia 300LRs (since designated 312). Towards the end of that year the Corporation sold one of its 300-series aircraft to the Ministry of Supply, and ordered one more long range Britannia 312. Five of the 302s, it was decided earlier this year, would be brought up to long-range standard by installing full 312 wing tankage; their designation became 305.

The first order for the Britannia from an overseas operator came from El Al Israel Airlines in June 1955; three 313-series aircraft were ordered, with an option on two more. In October of the same year Canadian Pacific Airlines also placed an order for three Britannia 314s, with an option on a further five. In April 1956, C.P.A. increased their order to five aircraft, the option on five more remaining unchanged.

It is intended that the last two Britannias on option for C.P.A. will be powered by Bristol Orion (B.E.25) turboprop engines.

In addition to these orders from civil operators, Bristol has received orders from the R.A.F. for ten 253-series aircraft, and from the Ministry of Supply for three similar aircraft and one Britannia 300. To date total orders for the Britannia amount to 55 aircraft. Production is being shared by Bristol Aircraft and Short and Harland (Belfast), the latter company being largely responsible for the long-range Britannias. Other firms, such as Folland and Blackburn (Dumbarton) make major airframe portions.

At the time of writing five of B.O.A.C.'s 15 Britannia 102s had been delivered, and were scheduled to inaugurate passenger services on the Corporation's South African route by the autumn, on completion of the training and route-proving programme.


FUSELAGE PRESSURIZED TO DIFFERENTIAL OF 8.3 lb sq in OFF ENGINE COMPRESSORS
ALL FLYING CONTROL SURFACES SERVO-TAB OPERATED
REAR PRESSURE BULKHEAD
MAIN ENTRY DOOR
CENTRE TRANSFER TANK 1,160 imp gal IN FOUR CELLS
TURBINE EXHAUST
INBOARD FUEL TANK 1,633 imp gal IN THREE IMPREGNATED NYLON CELLS EACH SIDE
TOTAL FUEL CAPACITY 8,486 imp gal
DOUBLE-SLOTTED FLAPS
OUTBOARD FUEL TANK 1,570 imp gal IN FIVE CELLS EACH SIDE
INTEGRAL TRANSFER TANK 460 imp gal EACH SIDE
TYRES AND WHEELS FOR ALL-UP WEIGHT 170,000lb. MAXARET FITTED
DIA DE HAVILLAND HOLLOW STEEL REVERSIBLE CH AIRSCREWS
FLIGHT COPYRIGHT

22 Trim tab.
23 Servo tabs.
24 De-icing air duct.
25 Cyclic electric anti-icing mats.
26 Loran aerial.
27 Detachable plastic-sandwich floor panels.
28 Dinghy stowages.
29 Firewalls.
30 Tubular engine mountings.
31 Oil tank.
32 De-icing heat exchanger.
33 Compressor tappings to cabin-air and de-icing systems.
34 Air-conditioning cold-air unit and cooler.
35 Engine air intake.
36 Cowl de-icing air vents.
37 Spinners anti-iced electrically.
38 Fire access panels.
39 Oil-cooler intake.
40 One 50-kVA alternator on each engine (auxiliaries driven electrically).
41 Tailpipes and shrouds.
42 Icing inspection light.
43 Flap-operating screw-jacks.
44 Gravity-fuelling points.
45 Pressure-fuelling point under outboard nacelles.
46 Fuel vent system.
47 Fuel pumps.
48 Fuel gauge.
49 Float switch.
50 Vent valve.
51 Inspection panels.
52 Dripstick.
53 End-rib of integral tank.
54 Tank baffles.
55 Westland-Irving sealed-balance aileron.
56 Navigation lights.

1 Fibreglass radome over Ekco cloud/collision-warning radar.
2 Radar access door.
3 Nosewheel doors, closed on ground.
4 Nosewheel retraction jack.
5 Nosewheel steering tiller.
6 Electrically heated windscreen panels.
7 Direct-vision panels.
8 I.L.S. localizer and glide-path aerial.
9 Crew-escape hatch.
10 Doors open by pulling inwards and sliding to rear.
11 Occasional seats for cabin crew in vestibule.
12 Inwards pressure-relief valve.
13 Escape chute stowage and attachments.
14 Suppressed A.D.F. loops.
15 V.H.F. aerial.
16 Airscrew ice guard.
17 Step down to rear floor.
18 Escape hatches.
19 Elevator and rudder tab controls and gearboxes.
20 Aileron tab controls and gearbox.
21 Bar unit.

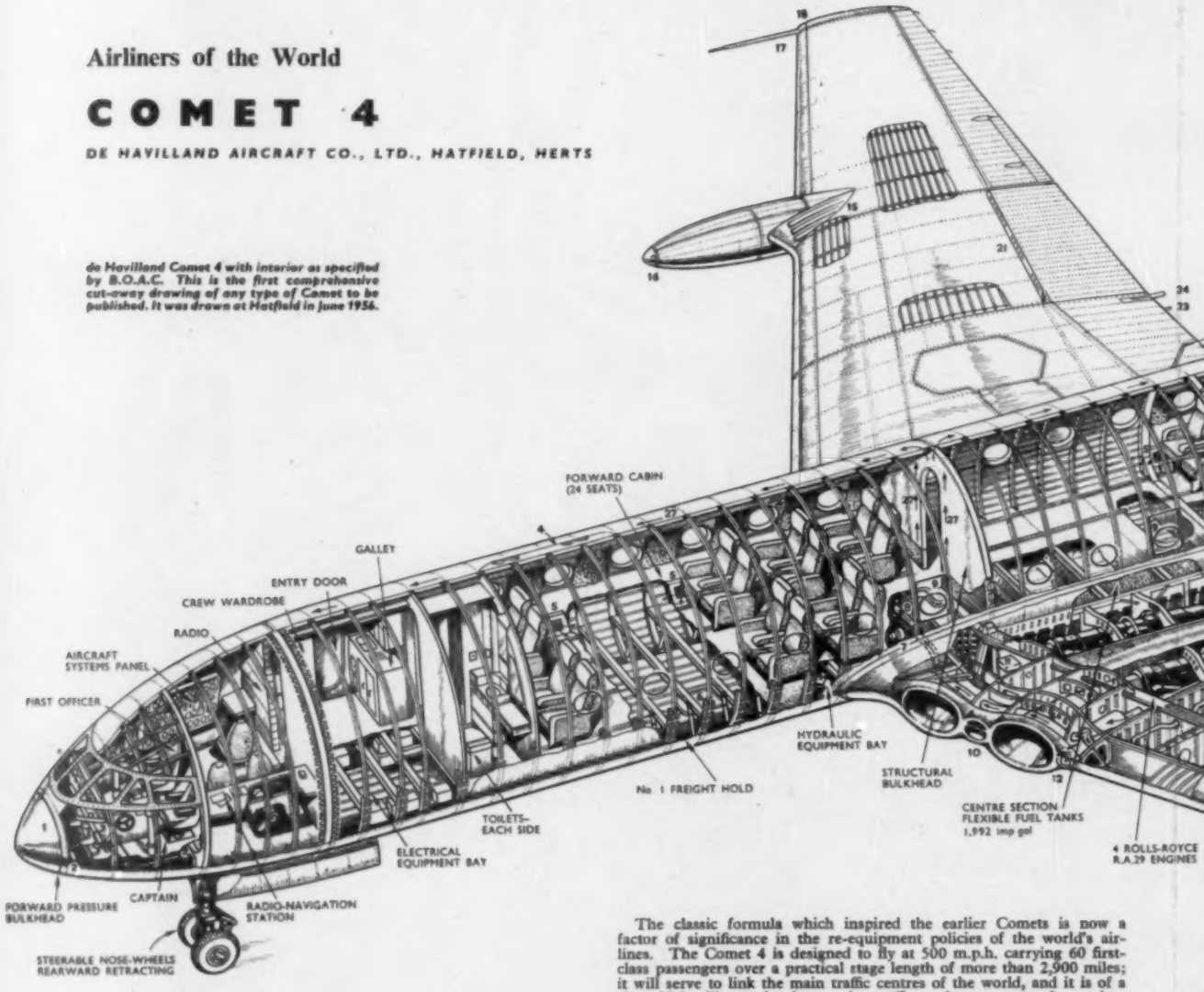
BRISTOL BRITANNIA 310
Four Bristol Proteus 755 of 4,120 e.h.p.

Dimensions: Span 142ft 3¼in; length, 124ft 3in; height on ground, 36ft 8.3in; gross wing area, 2,075 sq ft; total pressurized volume, 9,375 cu ft; total usable volume above floor, excluding flight deck, 5,877 cu ft; undercarriage track, 31ft.
Weights: Maximum take-off weight, 175,000 lb.; max. landing weight, 129,000 lb; zero fuel weight, 118,000 lb; operating weight empty, 87,695 lb; manufacturer's weight empty, 82,537 lb; capacity payload 28,000 lb.
Performance: Take-off distance to 50ft, all engines, standard conditions, 6,180ft; landing distance from 50ft, standard conditions, 127,000 lb, 3,275ft; range, still air, 28,000 lb payload, standard conditions, 4,758 st. m; cruising speed (mean), 391 m.p.h. T.A.S.; cruising altitude, "cruise-climb" to 31,000ft.

Airliners of the World

COMET 4

DE HAVILLAND AIRCRAFT CO., LTD., HATFIELD, HERTS



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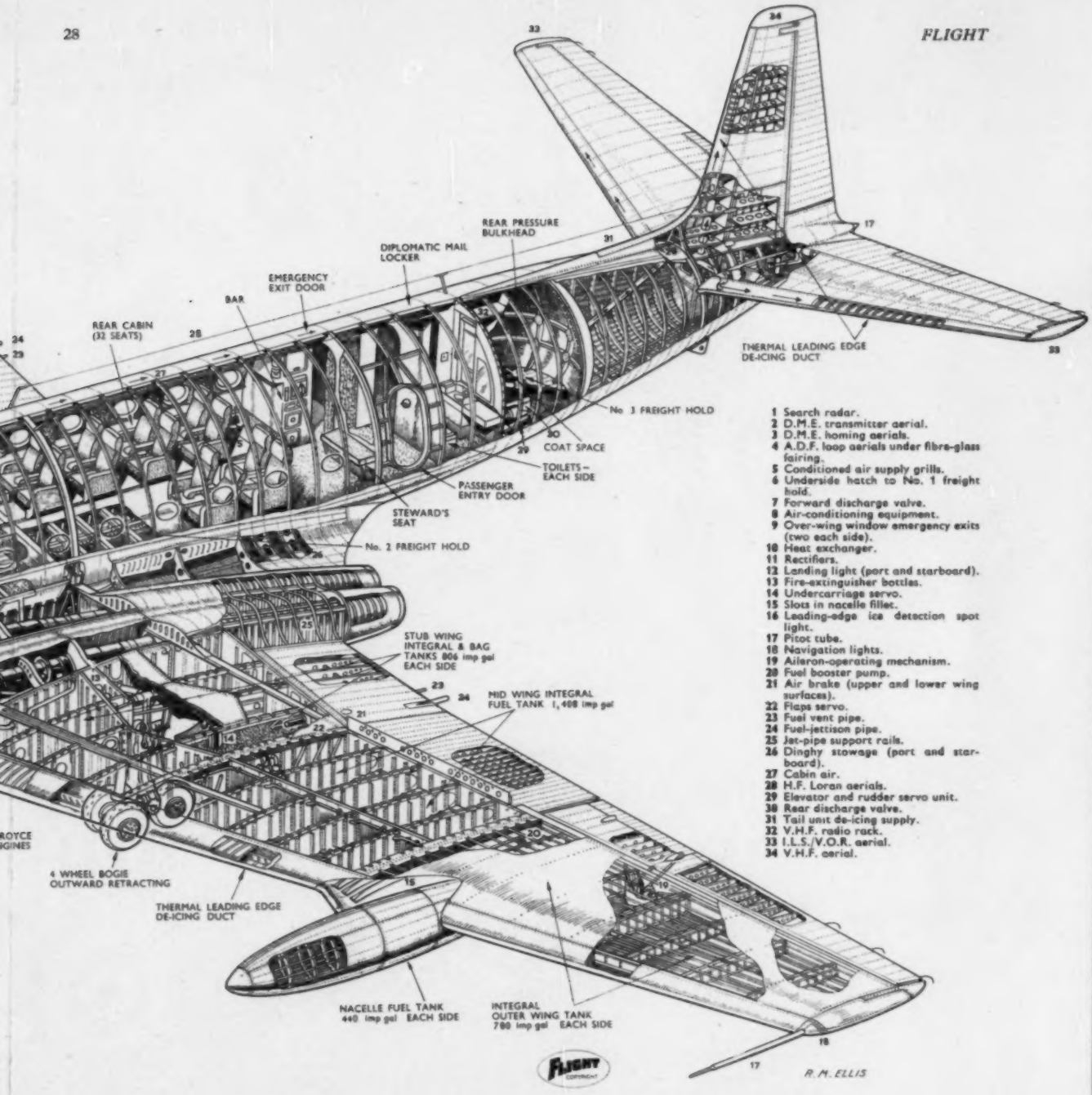

REAR PRESSURE BULKHEAD
DIPLOMATIC MAIL LOCKER
EMERGENCY EXIT DOOR
BAR
REAR CABIN (32 SEATS)
THERMAL LEADING EDGE DE-ICING DUCT
No. 3 FREIGHT HOLD
COAT SPACE
TOILETS – EACH SIDE
PASSENGER ENTRY DOOR
STEWARD'S SEAT
No. 2 FREIGHT HOLD
STUB WING INTEGRAL & BAG TANKS 806 Imp gal EACH SIDE
MID WING INTEGRAL FUEL TANK 1,408 Imp gal
4 WHEEL BOGIE OUTWARD RETRACTING
THERMAL LEADING EDGE DE-ICING DUCT
NACELLE FUEL TANK 440 Imp gal EACH SIDE
INTEGRAL OUTER WING TANK 780 Imp gal EACH SIDE
R. M. ELLIS

1 Search radar.
2 D.M.E. transmitter aerial.
3 D.M.E. homing aerials.
4 A.D.F. loop aerials under fibre-glass fairing.
5 Conditioned air supply grills.
6 Underside hatch to No. 1 freight hold.
7 Forward discharge valve.
8 Air-conditioning equipment.
9 Over-wing window emergency exits (two each side).
10 Heat exchanger.
11 Rectifiers.
12 Landing light (port and starboard).
13 Fire-extinguisher bottles.
14 Undercarriage servo.
15 Slots in nacelle fillet.
16 Leading-edge ice detection spot light.
17 Pitot tube.
18 Navigation lights.
19 Aileron-operating mechanism.
20 Fuel booster pump.
21 Air brake (upper and lower wing surfaces).
22 Flaps servo.
23 Fuel vent pipe.
24 Fuel-jettison pipe.
25 Jet-pipe support rails.
26 Dinghy stowage (port and starboard).
27 Cabin air.
28 H.F. Loran aerials.
29 Elevator and rudder servo unit.
30 Rear discharge valve.
31 Tail unit de-icing supply.
32 V.H.F. radio rack.
33 I.L.S./V.O.R. aerial.
34 V.H.F. aerial.

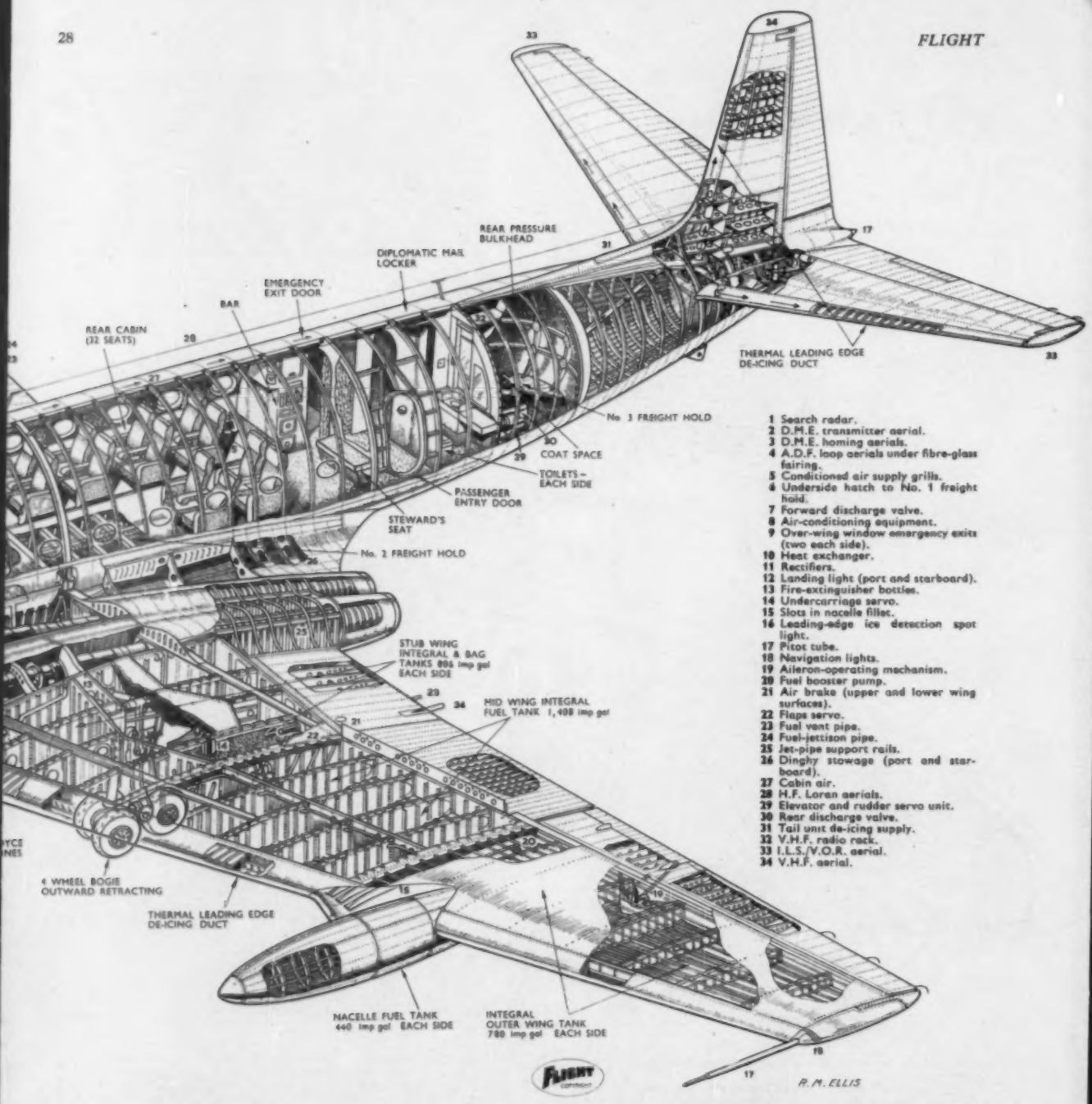
tively house and separate the majority of the equipment associated with the aircraft electrics and hydraulics. Generous provision is made for maintenance and servicing.

The wing is of cantilever construction comprising a centre-section, two stub wings, and two extension wings. The centre-section is a two-spar structure and is an integral part of the fuselage, incorporating attachments for the stub wings. The centre-section is not pressurized and accommodates four flexible fuel tanks. The stub wings are also two-spar structures and carry the engines and the main undercarriage, integral and flexible fuel tanks, and de-icing leading edge ducts. Engine bays are separated by titanium bulkheads. The stub wings also carry part of the flaps, which are of the split type underneath the engines and of the plain type outboard, and the airbrakes.

The extension wings are attached to the stub wings by fore and aft bolts extending between the spars. The extension wings carry the ailerons and the outboard section of the flaps, the integral fuel tanks, nacelle-type fuel tanks and de-icing ducts.

The fin and tailplane are of conventional construction. The main undercarriage gear, of de Havilland design, consists of two four-wheel assemblies, and a two-wheel steerable nose-gear. Retraction, steering and braking are hydraulic. The main gear shock absorbers are oleo-pneumatic struts operating from both beams of the bogie and with a trimmer damping strut operating from the rear beam. The nose undercarriage incorporates a single oleo-pneumatic shock strut. The doors of the main undercarriage are operated hydraulically and are arranged to be shut when the undercarriage is extended. The doors of the nosewheel are opened and closed mechanically. A good point is that all wheel doors are positively locked up mechanically. The wheel brakes are Dunlop disc units incorporating the Maxaret anti-skid device. The nosewheel is self-centring with a steering range of 59 deg on either side of neutral; steering can be unlocked to permit the nosewheel to turn through 360 deg for towing. A tail bumper beneath the tail protects the structure in the event of a tail-down landing.

POWERPLANT. The Comet 4 is powered by four Rolls Royce Avon RA.29 jet engines of 10,500 lb thrust each. They are mounted between the front and the rear main spars of each stub wing, insulated


REAR PRESSURE BULKHEAD
DIPLOMATIC MAIL LOCKER
EMERGENCY EXIT DOOR
BAR
REAR CABIN (32 SEATS)
THERMAL LEADING EDGE DE-ICING DUCT
No. 3 FREIGHT HOLD
COAT SPACE
TOILETS – EACH SIDE
PASSENGER ENTRY DOOR
STEWARD'S SEAT
No. 2 FREIGHT HOLD
STUB WING INTEGRAL & BAG TANKS 806 Imp gal EACH SIDE
MID WING INTEGRAL FUEL TANK 1,498 Imp gal
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THERMAL LEADING EDGE DE-ICING DUCT
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FLIGHT COPYRIGHT
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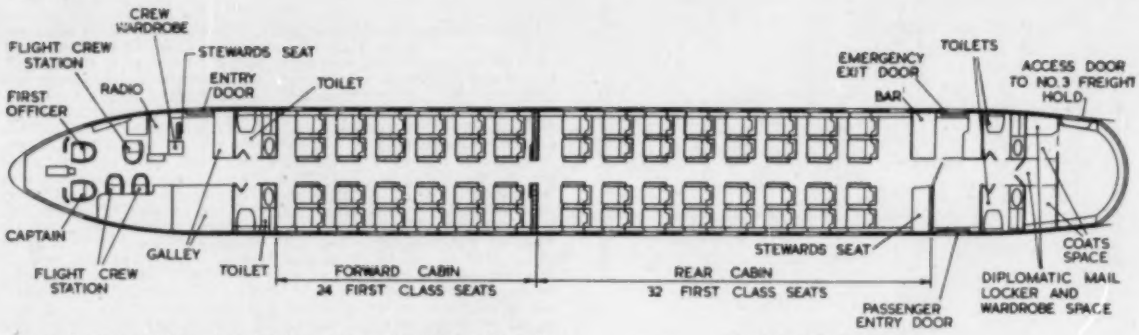


from each other and from the adjoining structure by titanium firewalls. Each engine is secured by two trunnion pads and tie-rods. Two quick-disconnect fittings secure air intakes and roller-mounted jet pipes. Each engine is an interchangeable unit capable of being readily removed and replaced without disturbing controls. Components, as far as possible, are interchangeable between each installation with the exception of the jet pipes (although inboard pipes and outboard pipes are interchangeable). The underside of each engine is completely exposed for servicing by large hinged doors, and further access panels are provided above for slinging and for accessory servicing. Most of the accessories, however, are on the underside of the engine and, together with the engine mountings, they are accessible from ground level. Engine control is by means of steel cables.

Particular care has been given to cooling, ventilation and de-icing. The compressor zone is cooled by its own intake/outlet system, and the combustion zone has two further air intake/outlet systems. The engine bays are divided by transverse firewalls into separate zones, each with its own fire-detection and fire-extinguishing system. A fuel collector-box of the "self-consuming" type is fitted.

A mechanical thrust-reverser system, to be fitted to the jet pipes of two engines, is under active development.

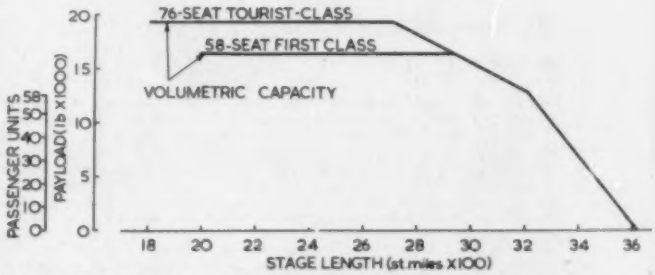
SYSTEMS. Cabin Air. The air supply for pressure-conditioning the cabin is tapped from the compressors of each engine; one engine is sufficient to maintain cabin pressure and conditioning to the required level. Only cooling is necessary, and this is accomplished by air heat-exchangers and turbine-expander refrigerators of D.H. design.

The maximum cabin pressure differential is 8¾ lb/sq in (8,000ft at 45,000ft). Discharge valves control the pressure and automatically dispose of used air. Two relief valves limit maximum differential pressure to 9 lb/sq in and also prevent negative pressure of more than ½ lb/sq in during a rapid descent. The system is designed for an ultimate pressure of twice normal.

Air is drawn from the cabin at the rate of approximately 1,200 cu ft/min and re-circulated with the incoming fresh air. Cabin air is changed completely twenty times per hour and total ventilation is at the rate of not less than 2 to 3 lb of conditioned air per min per person. Temperature is automatically controlled between 60 deg F and 75 deg F over a range of outside temperatures of −94 deg F to 86 deg F. A humidifier maintains humidity at a minimum of 20 to 30 per cent. Cabin windows are protected from internal mist by silica-gel containers which dry the air before it enters the sandwich.

Pressure control is fully automatic, it being necessary only to pre-select the altitude at which it is required to start pressurizing. This takes care of operation from airports of varying altitudes. Spill valves provide basic pressure control, and mass flow and temperature valves, controlled automatically with manual adjustment, regulate air conditioning. Provision is made for the attachment of a standard air conditioning connection on the ground; there is also a connection for ground pressurization tests.

Electrics. The main electrical supply is from a single-wire earth return system operating on a nominal 28-volt D.C. The aircraft structure acts as the earth. The whole system has been fused and engineered to eliminate as far as possible the likelihood of failure, and the following safety features are noteworthy: (1) Normal distribution is from a single busbar which in the event of failure automatically splits into two parts. Services are then maintained by the good half. (2) Certain essential loads—flight instruments, radio—are provided with a secondary busbar in the unlikely event of failure of the above. (3) Should this secondary distribution fail, essential services may be switched to the emergency batteries for a limited time, during which it should be possible to get at least one alternator back on the line.



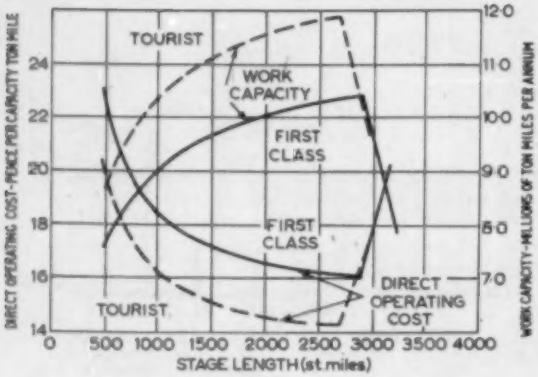
Power is supplied by four engine-driven 14 kVA alternators, the three-phase output of each being rectified and paralleled before rectification. Each alternator has a continuous rectified output of 350 amp maintained at 28 volts by carbon-pile regulators. Six 24-volt, 25-amp-hr batteries are installed with switching for series-parallel working; they are in two groups of three, each group being connected to each half of the distribution system; one battery in each group constitutes the reserve. Five of the batteries are connected in series with a switch for internal engine-starting. D.C. inverter sets provide A.C. at 115 volts 400 cycles three-phase for auxiliary power and at 26 volts 400 cycles single-phase by transformers. Sockets for external ground power are provided, and fuses and circuit-breakers are mounted in the control cabin. Crash and inertia switches simultaneously cut off the alternators, isolate the batteries, discharge fire-extinguishers and actuate a time-delay switch which finally disconnects all circuits except emergency lighting.

Hydraulics. The hydraulic system operates the flying controls, undercarriage retraction, flaps, air brakes, wheel brakes and nosewheel steering. Normal pressure is 2,500 lb/sq in. A single bay under the floor houses as much as possible of the equipment; this compartment, which is accessible during flight, is isolated from possible sources of ignition. The system comprises four separate circuits, where necessary with independent reservoirs and accumulators, with a colour code as follows:

Green: Supplied by pumps driven by the port inner and starboard outer engines, and serving undercarriage retraction, nosewheel steering, flaps, air brakes and wheel brakes. It also provides stand-by power for the flying controls.

Blue: Supplied by pumps driven by the starboard inner and port outer engines and providing primary power for the flying controls.

Red: A stand-by system, supplied by an electrically driven hydraulic pump, providing emergency operation of the undercarriage, flaps and


TOURIST
WORK CAPACITY
FIRST CLASS
FIRST CLASS
DIRECT OPERATING COST
TOURIST
DIRECT OPERATING COST-PENCE PER CAPACITY TON MILE
WORK CAPACITY-MILLIONS OF TON MILES PER ANNUM
STAGE LENGTH (st. miles)
0 500 1000 1500 2000 2500 3000 3500 4000
14 16 18 20 22 24
7·0 8·0 9·0 10·0 11·0 12·0

Airliners of the World

COMET 4

wheel brakes through independent lines. A hand pump in this circuit provides a further emergency method of lowering the undercarriage.

Yellow: This system is the second emergency supply for the flying controls. It is fed by an electrically driven pump and powers the secondary rams of the flying controls through separate lines.

Fuel. Four flexible bag-type tanks are fitted in the centre section; two integral and one bag tank are fitted in each stub wing; five integral tanks are installed in each extension wing; and the external nacelle tank is fitted on each extension wing leading edge. The total fuel capacity is 8,766 gallons. Considerable development has gone into the ventilation of the fuel tanks. Supply to the engine is by duplicated immersed electric pumps which can be removed without draining the tanks. Fuel heating is provided to eliminate fuel blockage due to icing. Switches in the cockpit control the fuel supply from each tank and there is a manually operated cross-feed valve. Contents gauges and flow-meters permit straightforward operation of the approved fuel-management procedure. Quantity gauges are of the capacitance type, and an "integrating" flowmeter indicates in the control cabin total "fuel-gone." The jettisoning system discharges fuel from extension pipes from each wing trailing-edge. Refuelling is accomplished *via* under wing connections on the port and starboard stub wings which are connected to the fuel tanker or hydrant. Fuel control is from each main undercarriage wheelwell, where the refuelling panel is located. Safety valves installed in each tank prevent the building-up of excessive pressures, and dripsticks provide a visual means of checking fuel levels. Refuelling rate is 200 Imp gal/min through each point.

De-icing. Protection of the wing, tailplane and fin leading edges and air intakes against ice is accomplished by means of hot air tapped from the engine compressors. Electrical protection of the windscreen is under development; pitot heads are protected electrically, and static lines are arranged so that any moisture they contain cannot freeze.

Flight Deck. A typical arrangement of the control cabin provides for captain, first officer, engineer, radio officer, and navigator, although it is unlikely that operators will require five crew members. On the port side of the flight deck is the radio navigation station, and on the starboard side the panel controlling aircraft engineering services. The former station has a spacious chart table and generous stowage room. A periscope sextant is maintained in the roof above. The pilot's instrument panel is of uncommon simplicity: two flight panels provide flight instrumentation laid out in conformity with modern standards. Warm air enters *via* a perforated pipe at floor level, and beneath the windscreen for de-misting as required. The central control pedestal incorporates trim controls, flap lever, air brake lever, undercarriage retraction lever, and auto-pilot control. Provision is made for a Flight Director system combining auto-pilot with navigation and approach aids. Controls for the engines including throttles and fuel gauges (high pressure and low pressure) are mounted on the central control pedestal.

Flying Controls. The flying control system is mass-balanced and operated by hydraulic means. A q-feel device provides artificial feel proportional to air speed for the elevator circuit. Operation of the control surfaces is by means of three duplicated hydraulic servo units, one for each control. Each unit consists of duplicated hydraulic rams, the movement of which is controlled by duplicated valves operated by steel cables from the control columns. Normal operation is by one ram only, the other being reserved for emergencies. Control of elevators, ailerons and rudder is in fact triplicated hydraulically and duplicated mechanically. Trim is accomplished by changing the datum of the stick self-centring mechanism. Included in the elevator circuit is a gear-change unit to adjust elevator movement to suit low speed and high speed conditions.

The flaps are operated by three hydraulic power units, mechanically interconnected; air brakes are extended and retracted by double quick-action hydraulic rams and can be applied at any speed up to limiting speed.

Radio and Radar. The type of radio and radar equipment fitted in the Comet 4 is variable according to requirements and a wide flexibility of choice is available. H.F. communication is by either duplicated transmitters and tunable receivers, or by duplicated transceivers. V.H.F. communication is by duplicated transceivers or by duplicated transmitters with the receiver as a section of the I.L.S./V.O.R. receiver. Duplicated A.D.F. is provided. I.L.S. and V.O.R. equipment may be arranged to operate combined or as separate units; provision is also made for Loran and D.M.E. (1,000 Mc/s or 200 Mc/s) and an 18in airborne search radar scanner is located in the nose. Aerials are of the suppressed type where possible, with the notable exception of the two H.F. line aerials.

PAYLOAD ACCOMMODATION. The passenger cabin is in two parts: a forward cabin about 25ft in length, and a rear cabin of about 30ft. Width and headroom of each cabin are constant at 9ft and 6½ft respectively. Standard chair units are mounted on permanent seat rails set at the international track of 31.7in, enabling different arrangements to be achieved easily. The standard arrangement is for 56 passengers (first class), and other arrangements are offered, e.g.: 76 passengers (tourist), and a mixed-class version (59 passengers, 24 first-class forward and 35 tourist-class aft in which the two cabins are separated by the galley, with toilets and washrooms fore and aft). All seats are forward of the jet pipes. Passengers enter *via* a 56in by 30in entry door on the aft port side into a vestibule off which lead a wardrobe, and two toilets accessible respectively through comprehensively equipped ladies' and gentlemen's dressing rooms. The galley at the forward end of the aircraft just aft of the flight deck includes two ovens, cold boxes, sink and spacious working table-tops. Amenities in the passenger cabin include a bar, and a convertible lounge which can be offered as an optional extra to enable operators (at the expense of six passenger seats) to convert the forward end of the cabin into a luxurious bar-lounge.

The Comet's chairs are of D.H. design. They are double units which, fully equipped, weigh only 50 lb, the triple chair for five-abreast tourist travel being only a little heavier. This weight includes allowances for seat belts, tables, etc.

Seven emergency escape exits are provided as follows: four removable window hatches, an emergency door opposite the main entry door, and crew entry door.

There are three freight holds: two under the floor, one forward of the centre section (160 cu ft) the other aft (230 cu ft). Each of these is accessible *via* a 31½ by 26in elevating door. The third freight hold (190 cu ft) is at the extreme aft end of the cabin up against the pressure dome. This hold is accessible through its own freight door on the starboard side of the fuselage.

COMMERCIAL HISTORY. The early Comet 1 entered service with B.O.A.C. in May 1952. Powered by D.H. Ghost jet engines, it had an all-up weight of 105,000 lb and seating for 36 passengers. An improved variant, designated Comet 1A, with increased tankage and an all-up weight of 110,000 lb, entered service with U.A.T. and Air France in the following year. (Deliveries of this type were also made to the Royal Canadian Air Force). Up to the time of their withdrawal from service, as a result of the accidents in January and April 1954, Comets had flown a total of 30,000 revenue hours.

In 1950, a year after the trials of the Ghost-powered Comet 1 began (July 1949), it was foreseen that Rolls-Royce Avon axial turbine engines, of greater power and efficiency and of lower consumption than the centrifugal-compressor Ghosts, would be available to supersede the Comet 1 earlier than had been expected. Design work on the installation of Avons in a modified Comet 1 was put in hand, and this version flew in February 1952.

Sales of the Comet 1 were limited to 21 aircraft, and the first production Comet 2, with improved payload-range performance (all-up weight 120,000lb), came off the production line in August 1953. This version had a commercial stage-length with full payload and fuel reserves of about 2,300 miles.

Continued rapid development of the Rolls-Royce Avon had already, by 1952, enabled a longer-ranged partner to the Comet 2 to be offered. This version, the Comet 3, was again a further improvement of the breed, offering full-payload (16,000 lb) to be carried for stage-lengths of about 2,600 miles. It had a fuselage 15ft longer than the Comet 2 (which was itself a 3ft stretch of the Comet 1), and the experimental prototype, powered by Avon RA.29 engines, made its first flight in July, 1954. Externally, this prototype resembles the Comet 4.

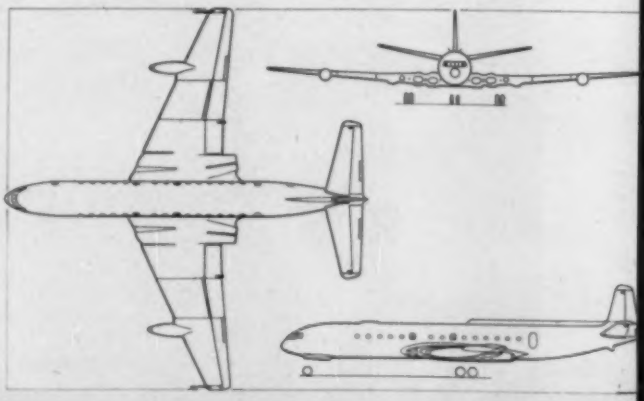
By the turn of 1954 the results of the national Comet investigation and inquiry were known, and the decision was made to build into a new Comet 4 all the accumulated experience gained since the early Comet flew in 1949. An order for a fleet of 20 was placed by B.O.A.C. for delivery starting in 1959.

The Comet 2, now in service with R.A.F. Transport Command (who are to have ten for world-wide strategic transport duties), will further extend Comet operating experience before the Comet 4 enters commercial service.

Dimensions. Span, 115ft; length, 111ft 6in; wing area, 2,121 sq ft; overall height, 28ft 6in; wheel track, 28ft 2in.

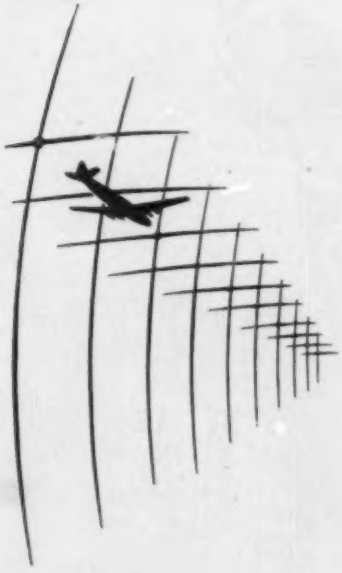
Weights. Max. take-off weight, 152,500 lb; max. landing weight, 113,000 lb; max. zero fuel weight, 92,000 lb; equipped tare weight, 68,400 lb (58-seater), 68,685 lb (76 seater); capacity payload, 16,401 lb; (58-seater), 19,299 lb (76-seater).

Performance. Take-off field length, standard conditions, 152,500 lb, 6,380ft; landing field length, standard conditions, 113,000 lb, 6,200ft; stage-length with 58-seat first-class capacity, 16,500 lb, 2,950 st. miles (see graph); cruising speed, 506 m.p.h. ($M = 0.74$); cruising altitude, 33,800ft to 41,000ft.



SMITHS FLIGHT SYSTEM

provides 17 functions with only 8 panel-mounted instruments



Smiths Flight System, for the instrumental control of transport aircraft, offers airline operators a system which integrates 17 functions and presents them on only 8 panel instruments. The system is designed for manual, Flight Director or fully automatic operation with Smiths Autopilot, and the presentation displays all the necessary information for flight control from take-off to touch-down under visual or I.F.R. conditions.

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- *Radio beam displacement information presented in relation to aircraft heading.*
- *Duplicated Flight Director facilities superimposed on the artificial horizon displays.*
- *Duplicated heading selection facilities common to both Flight Director and Autopilot on primary compass indicators.*
- *Common function selection for radio coupling for both Flight Director and Autopilot.*
- *Single knob control for standard Air Traffic Control manoeuvres when using Flight Director or Autopilot.*

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CARAVELLE

SOCIÉTÉ NATIONALE DE CONSTRUCTIONS AÉRONAUTIQUES DE SUD-EST, PARIS

THE S.E.210 Caravelle is the result of one of the specifications formulated in 1951 by the French Air and Transport Ministries, together with representatives of the aircraft industry and of the French airline. The specifications were issued in November 1951, and one of them called for a medium-range gas turbine transport, either turbojet or turboprop. The original requirement was for an aircraft capable of transporting between six and seven tons of payload over ranges of between 900 and 1,200 miles at a block speed of more than 380 m.p.h.

The choice of engine, turbojet or turboprop, was left entirely free, and since French engine development at that time was entirely military it appeared that the engine, whatever its type, would have to be bought from abroad.

S.N.C.A.S.E. were from the first in favour of the faster pure jet which they believed would be more than a match for a turboprop aircraft from the point of view of economics. Several projects were submitted, one of them making use of the French Atar turbojet. It was as a result of the first studies of this version that the unusual engine arrangement was decided on; in view of the Atar's 6,170 lb thrust, three would have had to be used, and since the third engine would obviously have to be installed on the centre-line, the tail suggested itself as a location for grouping all three engines. The advantages of this layout are related later.

In 1952 it became apparent that Rolls-Royce engines of suitable power would be available at the right time, and it was decided to draft a project making use of a late mark of Avon. The thrust which could be expected was more than 9,000 lb, and it was considered that two engines delivering this power would be adequate. It might be argued that if three Avons had been installed the Caravelle's performance and range would have been greatly increased, but this would have gone beyond the original medium-range specification. Final S.N.C.A.S.E. proposals were submitted in June 1952 and official approval was granted in September.

The company was able to draw upon de Havilland's Comet experience, and has in fact maintained close liaison with the English company. Several features of the aircraft, including systems and structural fatigue design, were prepared in the light of de Havilland experience. Air France helped constructively in the development of the Caravelle and technicians and a pilot from the airline were attached to S.N.C.A.S.E. to maintain continuous co-operation between the two organizations.

The Caravelle was designed to comply with the United States civil air regulations in order to qualify it for an American C. of A. and at the same time as the corresponding French certificate; American standards were observed in all parts requiring break-down for maintenance purposes, and accessories and equipment were selected from only those most widely used and proven. The British aircraft industry contributed considerably and the firms which had a part in the Caravelle's design, besides de Havilland and Rolls-Royce, include Lockheed, Dunlop, Hobson, Venner, Teddington Controls, Self-Priming Pumps, Flight Refuelling, and Graviner. A particular feature of the design is the provision made for freight, a large hydraulically operated door being situated on the forward port side of the fuselage and the floors all suitably reinforced, so that full payload could always be made up during seasonal passenger traffic fluctuations.

AIRFRAME. The fuselage is a stressed skin structure, of cylindrical sections for half its total 104ft length. The pressurized section measures 83ft 6in and has a volume of just over 6,000 cu ft. There are 28 windows, 11 of which are inward opening escape hatches. The two under-floor freight compartments are of 434.3 total cubic feet capacity. Entry is by a retractable stairway under the tail; freight is loaded through a 6ft 6in by 5ft 11in hatch on the port side forward. The nose-section up to frame seven (total number of fuselage frames is 75) is a standard Comet nose. The engines are mounted to frames 53 and 56, and the wing pick-ups from frames 31 and 35. The windows are of "curvilinear triangular" shape, this form having been determined to improve downward view; an 88 lb saving in weight compared with rectangular windows was achieved.

The principal load-carrying structure of the wing is a three-spar torsion box containing the integral fuel tankage and to which are attached the seven drooped leading-edge sections, two aileron sections per side, and a total of eight flap sections. The torsion box is built up from the upper and lower skins, the lower skin being built up with ribs and centre spar web for joining to the upper skin with the spar booms but without ribs. Access panels to the fuel tanks are provided. The undercarriage legs are mounted on a heavy structure behind the rear spar, their loads being transmitted to the torsion box by a specially reinforced rib. The flaps extend outwards and downwards on rails, and are operated by screw-jacks. Automatic slot shrouds are fitted. The air brakes extend above and below the wing. The aerofoil section is N.A.C.A. 651212.

The fin is built up to the level of the tailplane as an integral part of the fuselage, the dorsal fin being added afterwards. The tailplane, built in one piece, is bolted on top. Above this is the fin, a conventional two spar structure. The tailplane structure is similar to that of the wing, the upper and lower halves being jointed together to form a torsion box.

The main undercarriage gear comprises two four-wheel bogies, suspension being provided by a main shock strut and an auxiliary strut. The main wheels retract inwards, partly into the wing and partly into the fuselage, and are locked mechanically in both up and down positions. Tyre inflation pressure is 96 lb/sq in. Tyres, hydraulic brakes and Maxaret anti-skid devices are by Dunlop. The nose gear is a dual-wheel unit mounted on a swivelling axis and a shock strut; it retracts forwards and is steered hydraulically (100 deg total steering range).

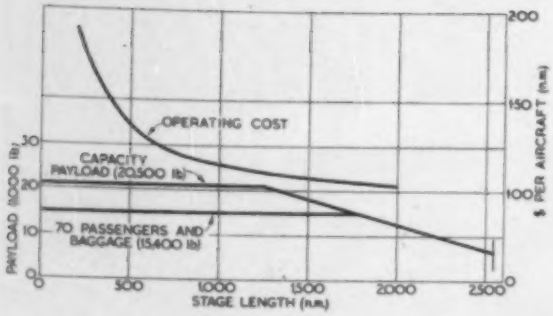
POWERPLANT. Advantages of the unconventional engine installation of the Caravelle—two podded Rolls-Royce RA.29 Avon engines mounted on either side of the rear fuselage—are as follows: (1) The wing is aerodynamically clean from root to tip. (2) Fire risk is reduced by separation of fuel and engines. (3) Cabin noise levels are low. (4) The change of air intake incidence with wing incidence is half that for wing mounted engines. (5) Asymmetric thrust is negligible. (6) Thrust line is close to the centre of gravity, variations of thrust having little effect on longitudinal stability. (7) Such an installation lends itself to reverse thrust. (8) The engines are well clear of debris when on the ground.

The engines are interchangeable and easily removable and a hinged panel beneath each pod gives access to the accessories; those accessories which are not available from beneath are provided with appropriate access. Each mounting stub contains an auxiliary gearbox driving a generator and two hydraulic pumps. The air intake is de-iced thermally.

The engines are basically identical to the Rolls-Royce Avon RA.29s fitted to the de Havilland Comet 4.

SYSTEMS. Cabin Air. A differential of 8.05 lb/sq in (8.25 lb/sq in maximum), enables 8,000ft cabin altitude to be maintained when cruising at 40,000ft. The source of cabin air, in conformity with European jet-liner practice, are the engine compressors. Air from each is passed through a heat exchanger, turbine expansion unit and water extracter. Mounted close to each engine, cooling air for the two heat exchangers is taken through twin ram air intakes located at the base of the fin. Temperature control is automatic. The two supply systems lead to a distribution box beneath the cabin floor, which is divided into two, one part distributing air to the cabin and the other to the flight deck. Provision is made for the air conditioning system to be connected to a ground supply.

The cabin air system of the Caravelle was developed in association with AiResearch of America and most of the components were made by that company. There are three pressure discharge valves, two—installed at the rear of the cabin—being automatically regulated, the other, situated near the nosewheel bay, being manually operated. Each



valve provides automatic inward-pressure relief during rapid descents.

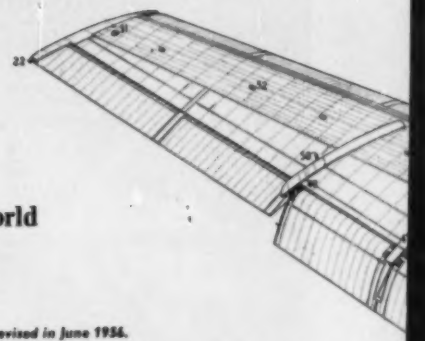
Electrics. There are three main circuits: a 28.5 volt D.C. system; a 26 volt 400 cycle A.C. system; and a 115 volt 400 cycle A.C. system. The electrical services are as follows: engine starters, fuel pumps and valves, emergency hydraulic pumps, flight instruments, windscreen wipers, defogging blowers, and de-icing and air conditioning valves. Each engine drives one 30 volt D.C. generator, having an output of 375 amp continuously or 400 amp for a 30 min period. The 115 volt A.C. circuit is supplied by two main inverters, plus one emergency inverter. The 26 volt A.C. circuit is supplied by the 115-V system through a transformer. Should the two generators fail to operate, the emergency inverter supplies A.C. essential to the flight instruments. Voltage regulation by carbon piles ensures a steady current. The aircraft battery is of 40 amp-hr capacity. An emergency 85 amp-hr battery ensures operation of the flying servo-controls and the fuel pumps. The complete electrical system may be supplied from the ground through an external 28 volt connector, and a separate 112 volt connector is used for engine starting. Circuit-breakers and fuses protect the system from overloads. The engines can be started from the internal batteries by switching the main stand-by block in series with the smaller aircraft block; they can be switched in parallel for emergency use.

Hydraulic System. The Caravelle has two main hydraulic systems. They are independent and operate at a pressure of 2,500 lb/sq in. In addition there are two emergency systems, each supplied by an electric pump. The two main systems are of course supplied by engine driven pumps, two for each system, each of which has its own reservoir and regulating and control circuit. A colour-code identifies each of the four systems; closely conforming to the Comet hydraulic system code, this is as follows: green, half of all the flying controls, undercarriage, flaps, airbrakes, wheel brakes, nosewheel steering and passenger steps; blue, powered controls and feel-simulation; yellow is a stand-by for the powered controls and feel simulation; and red is a stand-by for undercarriage lowering, flaps, wheel brakes, nosewheel steering, and is used normally to open the freight door. There are seven main permanently charged accumulators, one in the blue system (providing ten full deflections of all flying controls), another in the yellow system, three in the green system and two in the red circuit.

Fuel System. This is supplied by four integral tanks formed by the wing torsion box. Total capacity is approximately 4,070 gallons. Pressure refuelling from one point under each wing can be completed in about 15 minutes, filling operations being controlled from a panel located beneath the wing. Overwing filler caps for gravity refuelling are provided also. Fuel is drawn from each tank by two immersed electric pumps, which are removable without emptying the tanks, and fuel flow is controlled by a cross-feed system from the cockpit enabling either engine to be connected to any tank. Three capacity-type fuel gauges are fitted to each outer tank, and six to each main tank. In addition two dripsticks are provided. There is no provision for fuel-jettisoning, since the Caravelle's maximum landing weight is considered to be sufficiently close to the maximum take-off weight for this not to be necessary.

De-icing. The system is supplied by air bled from the engine compressors, and serves the leading edges of the wings and tail. The same sources provide for engine de-icing. The pitot-heads are protected from ice formation electrically, and the windscreen by alcohol spray. Windscreen de-misting is taken care of by silica-gel containers which dry the air at cabin pressure before entering the space between the panes.

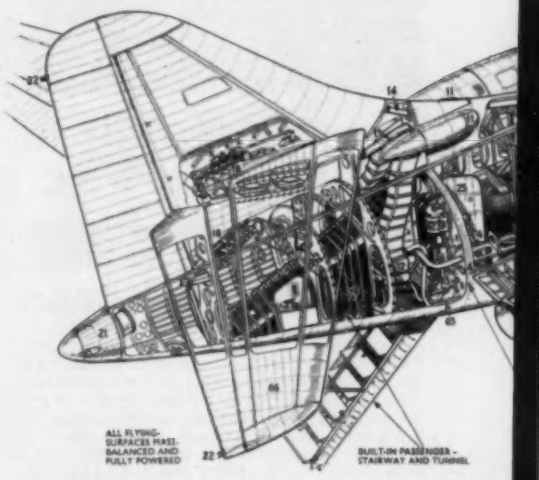
Flight Deck. Since the nose portion of the Caravelle is identical with that of the Comet, the flight deck conforms in layout very closely with that aircraft. Flight instruments are arranged in accordance with general commercial practice, each pilot having his own individual flight instrument panel, and the co-pilot's ability to gain easy access to radio communications (in the roof above and between the pilots), engine controls (on the floor control pedestal between the two pilots) and the engineering and ancillary services (starboard side), make it possible for the Caravelle to be flown with a crew of two. A third seat is provided with access to the navigational and engineering stations.



Airliners of the World

CARAVELLE

S.N.C.A.S.E. Caravelle.
Drawn at Toulouse in May 1955, revised in June 1956.

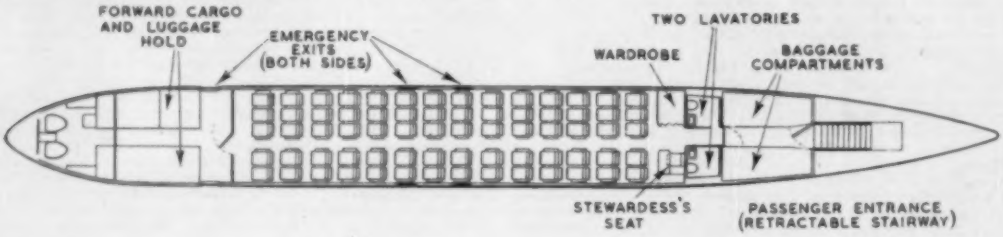


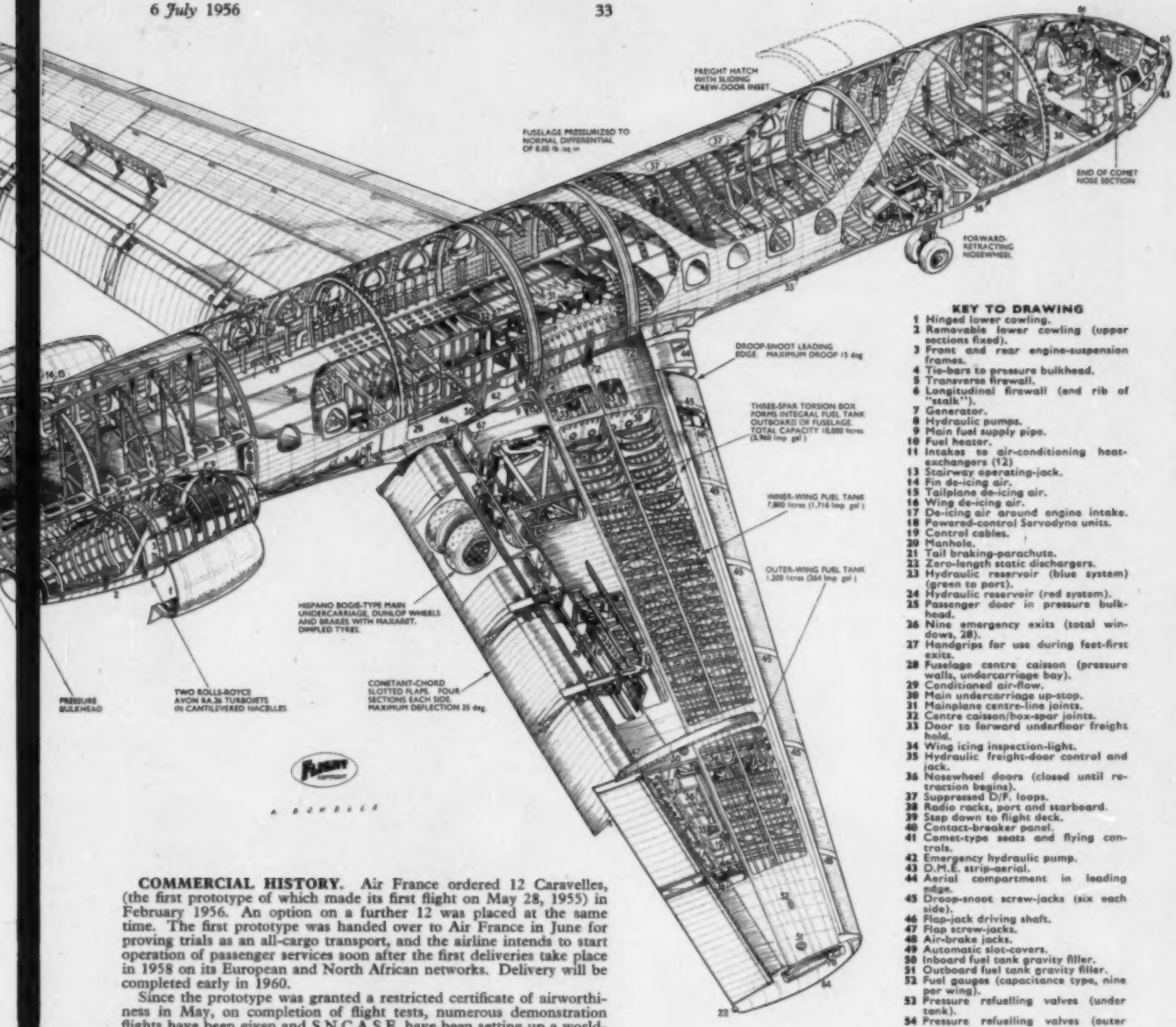
Flying Controls. All are hydraulically power operated, and have artificial feel proportional to air speed. Operation of each control is hydraulic by Servodyne boosters, whose valves are operated by cables from the control column. The Sud-Est designers have taken special care to reproduce artificial feel and a Hobson feel-simulator control, type 159, regulates hydraulic pressure in three "Q-pots" according to dynamic pressure sensed at the starboard pitot-head. A Lear autopilot is fitted.

Radio. This is adjustable according to customer requirements. A typical installation is as follows: H.F. transmitter/receiver; V.H.F. transmitter/receiver; radio compass; V.O.R. receiver; glide slope receiver; marker beacon receiver; incommunication. The aerials are located as follows: H.F. aerial is flush with the fin root; the A.D.F. loop is in a fairing on the fuselage top with the flush sense aerial in the bottom of the fuselage; the V.O.R. is flush with the fin; and the glide slope aerial is located behind the windscreen. The marker beacon aerial is located under the fuselage. All radio controls are accessible to the pilots.

PAYLOAD ACCOMMODATION. The standard seating layout accommodates 70 passengers at a seat pitch of 36.6in. The high density version allows for 91 passengers at a pitch of 35in. Total cargo capacity is 731 cu ft distributed among an upper front compartment between the cockpit and the passenger cabin (300 cu ft); an upper rear compartment (300 cu ft); a lower underfloor front compartment (194 cu ft); and a lower underfloor rear compartment of about 88 cu ft.

All seats are on rails to permit quick adjustment of pitch. The main passenger entry door is under the tail with a built-in retractable stairway. Freight can be loaded into the forward fuselage through a 6ft 6in by 5ft 11in loading door. The whole of the cabin floor is stressed to take 123 lb/sq ft. The bulkhead between the forward cargo compartment and the main passenger cabin is movable, allowing for four variations of cargo/passenger ratio, the number of passengers varying from 40 to 70.




FREIGHT HATCH WITH SLIDING CREW-DOOR INSET
FUSELAGE PRESSURIZED TO NORMAL DIFFERENTIAL OF 8.65 lb/sq in
END OF COMET NOSE SECTION
FORWARD-RETRACTING NOSEWHEEL
DROOP-SNOOT LEADING EDGE. MAXIMUM DROOP 15 deg
THREE-SPAR TORSION BOX FORMS INTEGRAL FUEL TANK OUTBOARD OF FUSELAGE. TOTAL CAPACITY 10,000 litres (2,960 Imp. gal.)
INNER-WING FUEL TANK 7,800 litres (1,716 Imp. gal.)
OUTER-WING FUEL TANK 1,200 litres (264 Imp. gal.)
HISPANO BOGIE-TYPE MAIN UNDERCARRIAGE. DUNLOP WHEELS AND BRAKES WITH MAZAWET. DIMPLED TYRES.
TWO ROLLS-ROYCE AVON RA.26 TURBOJETS IN CANTILEVERED NACELLES
CONSTANT-CHORD SLOTTED FLAPS. FOUR SECTIONS EACH SIDE. MAXIMUM DEFLECTION 35 deg
PRESSURE BULKHEAD
A. BUMBLE

KEY TO DRAWING

1 Hinged lower cowling.
2 Removable lower cowling (upper sections fixed).
3 Front and rear engine-suspension frames.
4 Tie-bars to pressure bulkhead.
5 Transverse firewall.
6 Longitudinal firewall (and rib of "stalk").
7 Generator.
8 Hydraulic pumps.
9 Main fuel supply pipe.
10 Fuel heater.
11 Intakes to air-conditioning heat-exchangers (12)
13 Stairway operating-jack.
14 Fin de-icing air.
15 Tailplane de-icing air.
16 Wing de-icing air.
17 De-icing air around engine intake.
18 Powered-control Servodyne units.
19 Control cables.
20 Manhole.
21 Tail braking-parachute.
22 Zero-length static dischargers.
23 Hydraulic reservoir (blue system) (green to port).
24 Hydraulic reservoir (red system).
25 Passenger door in pressure bulkhead.
26 Nine emergency exits (total windows, 28).
27 Handgrips for use during feet-first exits.
28 Fuselage centre caisson (pressure walls, undercarriage bay).
29 Conditioned air-flow.
30 Main undercarriage up-stop.
31 Mainplane centre-line joints.
32 Centre caisson/box-spar joints.
33 Door to forward underfloor freight hold.
34 Wing icing inspection-light.
35 Hydraulic freight-door control and jack.
36 Nosewheel doors (closed until retraction begins).
37 Suppressed D/F. loops.
38 Radio racks, port and starboard.
39 Step down to flight deck.
40 Contact-breaker panel.
41 Comet-type seats and flying controls.
42 Emergency hydraulic pump.
43 D.M.E. strip-aerial.
44 Aerial compartment in leading edge.
45 Droop-snoot screw-jacks (six each side).
46 Flap-jack driving shaft.
47 Flap screw-jacks.
48 Air-brake jacks.
49 Automatic slot-covers.
50 Inboard fuel tank gravity filler.
51 Outboard fuel tank gravity filler.
52 Fuel gauges (capacitance type, nine per wing).
53 Pressure refuelling valves (under tank).
54 Pressure refuelling valves (outer tank).
55 Pressure refuelling control panel (hinges down).
56 Inspection panels (open).
57 Mass balances (elevators similar).
58 Lower half-ribs (tops not shown).
59 Wing stringers (all extruded).
60 Nosewheel steering wheel.
61 Direct-vision panels.
62 Mainwheel door closed for ground clearance.
63 Fire-suppression bottles (not shown in this bay.

(Continued in previous column)

64 Detachable wing-tip.
65 Accommodation for collision warning radar and twin lights.
66 Spot-welded spanwise stringers, riveted ribs.
67 False rear spar.
68 Main undercarriage jack.
69 Seat-rails.
70 Tank air-vent float-valve.
71 Nosewheel jack.
72 Main-frame/box-spar joints.

COMMERCIAL HISTORY. Air France ordered 12 Caravelles, (the first prototype of which made its first flight on May 28, 1955) in February 1956. An option on a further 12 was placed at the same time. The first prototype was handed over to Air France in June for proving trials as an all-cargo transport, and the airline intends to start operation of passenger services soon after the first deliveries take place in 1958 on its European and North African networks. Delivery will be completed early in 1960.

Since the prototype was granted a restricted certificate of airworthiness in May, on completion of flight tests, numerous demonstration flights have been given and S.N.C.A.S.E. have been setting up a world-wide sales and service organization. A production rate of four aircraft per month is expected to be achieved, and production effort has been distributed between the three main nationalized French firms, S.N.C.A.S.E. actually building only 50 per cent of the aircraft themselves.

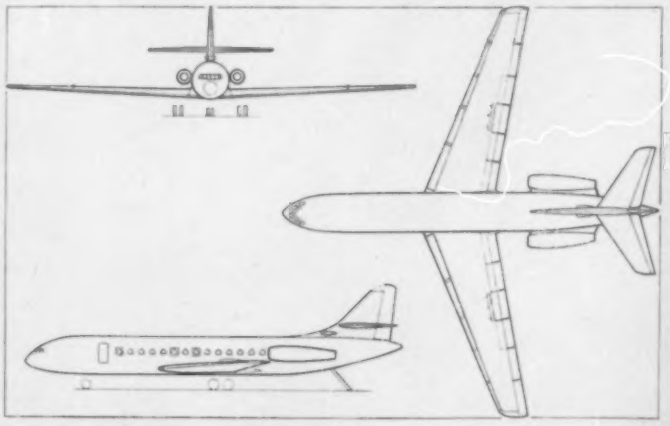
The Caravelle designers are already hinting at future developments, including the Caravelle 2 and Caravelle 3 and, they say, "one day perhaps a Super Caravelle, keeping pace with the normal trend of developments in civil aviation."

Weights and Performance. Max. take-off weight, 90,400 lb; max. landing weight, 86,000 lb, zero fuel weight, 72,700 lb; weight empty, 48,000 lb; operating weight empty, including 2 crew and 2 cabin crew, unusable fuel and water and hydraulic fluid, 49,377 lb; capacity payload, 20,500 lb; take-off field length at 90,400 lb, sea level, I.S.A., 5,650ft; min. take-off run, 3,750ft; landing field length, sea level, I.S.A., 86,000 lb, 6,000ft; min. landing run, 2,150ft; typical cruising speed, 420 kt; cruising altitude, 35,000ft to 42,000ft; max. stage-length with capacity payload and fuel reserves (see graph), 1,700 n.m.

S.N.C.A.S.E. 210 CARAVELLE

Two Rolls-Royce RA.29 Avons of 10,500 lb thrust

Dimensions: span, 112ft 6.4in; length, 104ft 10in; height, 28ft 6in; gross wing area, 1,579 sq ft; sweep angle, 20 deg at quarter chord; flap area, 265.8 sq ft; horizontal tail, 301.4 sq ft; vertical tail, 166.8 sq ft without dorsal fillet; undercarriage track, 17ft; wheelbase, 38ft 7in; fuselage outside diameter, 126in; pressurized volume, 6,120 cu ft.



Airliners of the World

ELAND-CONVAIR

D. NAPIER AND SON, LTD., LONDON, W.3.

UNTIL recently known as the Napier Eland Airliner, the Eland-Convair is a demonstration aircraft with which D. Napier and Son intend to convince present operators of Convair-Liners of the practicability of converting their equipment to Eland turboprop power. Conversion engineering started early last year and careful investigations have been made to determine the optimum form which it should take.

The original R-2800 nacelle and firewall are retained, and the installation of the Eland involves a minimum amount of disturbance. Each engine is supplied as a complete powerplant, port and starboard units being interchangeable. The engine picks up on four bolts at the firewall, the fittings being changed to steel construction. A stainless-steel intermediate firewall seals the compressor bay from the turbine section, and is bolted only to the engine pick-up points so that an engine-change does not affect the mounting structure and firewalls. The cowling is of the bonnet type, with inner skins of thin stainless steel and outer shells of light alloy. Exhaust gas leaves centrally and is taken up over the wing to a propelling nozzle at the trailing edge, the whole unit being covered by a Refrasil blanket. Between this blanket and the pipe is a stainless-steel jacket forming a 400,000 B.T.U./hr heat exchanger on each engine, this providing roughly 25 per cent more anti-icing air than is available in the basic CV-340.

A single drive-shaft transmits power to an accessory gearbox on the firewall. On the starboard side is a further drive to an AiResearch cabin blower. The oil system is contained in the second (compressor) fireproof bay, the tank being mounted on the front of the intermediate firewall immediately above the 8in-diameter Serck radial-flow cooler. The latter is housed in a separate duct fed with ram air from an intake under the cowling. Fire-protection equipment includes Graviner Firewire and C.B. bottles, two additional double-headed 12-lb bottles augmenting the existing system. Ice protection is inbuilt in the Eland, by hot-oil pads and bleed air; intakes are heated by Napier Spraymat electric elements and similar provision is made on the airscrews. Airframe and equipment changes are very few, although the existing design of alternator is replaced by a Rotax unit rated at 40 kVA on each engine. Engine controls are very straightforward, and comprise power lever, h-p. cock/dump valve/auto-pitch-coarsening/parking brake, and manual r.p.m. over-ride. These are served by the existing throttle, mixture and carb-air controls. For starting, a 120-volt D.C. system is employed.

Airscrews are de Havilland four-blade units of 13ft 6in diameter. Various types of Eland have been involved in the development flying, but the standard engine for future Convair conversions will be the NEl.6 of 3,600 e.h.p. A change to this engine brings about an overall weight-saving of some 2,000 lb; in addition, the extra 2,400 horsepower allows the Eland-Convair to fly right up to its structural-limit weight of 53,200 lb as a matter of course, enabling the capacity payload of 12,880 lb to be carried to just over 1,000 st.m. (see curve) instead of about 300 miles as in the CV-340.

The demonstration machine is now approaching the stage at which it can undertake overseas tours. Flying is almost up to 200 hours, and general handling and lack of trouble have been most encouraging. The aircraft is fully furnished, and in the new form is at least as quiet as before, in spite of the increased airspeed. It is hoped, with considerable confidence, that the life of the Eland will fairly rapidly reach 1,000 hr for hot parts and 2,000 hr for the remainder; the "package" sub-division of the basic engine is a great help in minimizing the man-hours required for routine servicing. Future plans for converting CV-340s are being worked out in close co-operation with Convair, and will probably involve the supply of equipment in kit form.

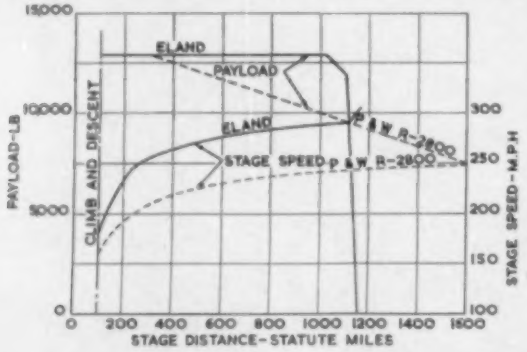
NAPIER ELAND-CONVAIR

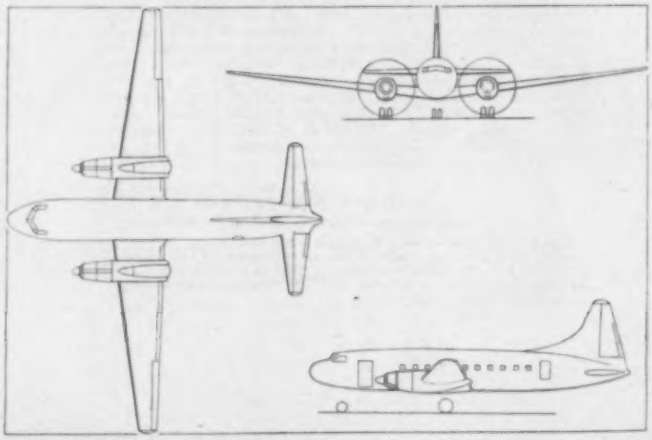
Two Napier Eland NEL6 of 3,600 e.h.p.

Dimensions: as for CV-440 (p.35).

Weights: empty, 28,321 lb, operating weight, 29,550 lb; zero-fuel weight, 44,000 lb; landing weight, 50,670 lb; maximum payload (space-limited), 7,260 lb, for 44 passengers, and 5,620 lb freight, totalling 12,880 lb; max. fuel with full payload, 10,556 lb (1,319 gal kerosine); maximum weight, 53,200 lb.

Performance (estimated): take-off field length (see p.10), 4,790ft at max. weight, or 3,820ft at 48,000 lb; climb to 15,000ft at 12,000 r.p.m. at 53,200 lb at 160 m.p.h. (e.a.s.), 12 min; cruise performance at 11,500 r.p.m., 285 m.p.h. at 30,000ft (1.4V $_{MD}$) at 46,000 lb with 0.212 n.a.m./lb fuel or 315 m.p.h. at 15,000ft at same weight at 0.148 n.a.m./lb or 328 m.p.h. at 25,000ft at 34,000 lb at 0.205 n.a.m./lb; landing field length, 3,200ft (2,240ft unfactored) at max. landing weight.





The New Comet

Frequency of service with high load factors
Operation from normal airfields
Progressively developed over seven years

DE HAVILLAND

The power of the Hunting Percival Pembroke

The Hunting Percival Pembroke, communications and training aircraft, is powered by two Alvis LEONIDES Engines. The Leonides Engine, acknowledged supreme in the 500-600 b.h.p. range, has proved its reliability in numerous other types of aircraft throughout the world.

ALVIS

LEONIDES 550 b.h.p. radial

ALVIS LIMITED · COVENTRY · ENGLAND

Sir W G Armstrong Whitworth Aircraft Ltd
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A great deal of design study, development, testing and production of these vital weapons for Britain's defence is being carried out by Armstrong Whitworth. With our great resources, and backed by the even greater resources of the Hawker Siddeley Group, the requirements specified for these weapons by the Armed Forces, will be duly satisfied. Other products for the Forces of the Free World coming from Armstrong Whitworth are the Javelin, day and night fighter; the Hunter, first choice for European defence and the Sea Hawk, the Royal Navy's latest fighter.
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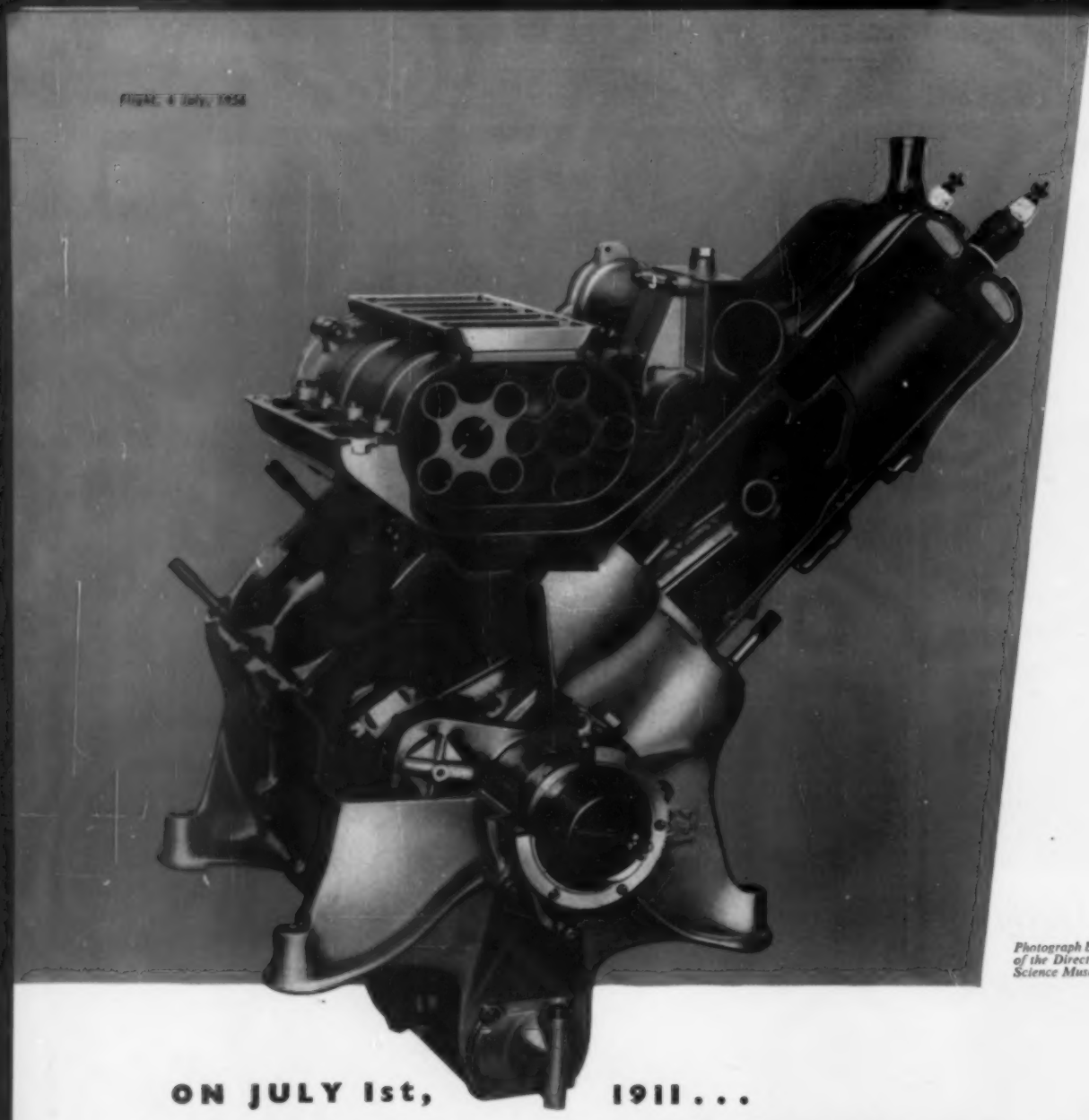


Photograph by courtesy of the Director of the Science Museum.

ON JULY 1st, 1911...

. . . 10,000 excited people gathered on the Royal Aero Club flying grounds at Eastchurch to watch the Gordon Bennett Cup air race. Among the array of aircraft Col. Alec Ogilvie's "Baby" Wright biplane aroused particular interest — it was powered by the first supercharged aero-engine. An eye-witness account of the "Baby's" performance says . . . "The new note in the 'music' of the two Wright propellers and the fact that the machine was a biplane, created fresh interest among the public and as she steadily kept round on her course at a fine speed of over 54 m.p.h. considerable excitement was kept up by the overlapping of the slower machines."

The New Engine Company's supercharged motor was introduced in 1910. It was made in various shapes and sizes but the sectioned version shown here is a four-cylinder two-stroke with a Roots three part blower mounted between the Vee cylinder arrangement. By an ingenious rotary sleeve valve pure air is first admitted to the cylinders when the inlet port is uncovered. This air drives out the old exhaust gases and forms a cushion for the mixture which follows. Only the centre part of the Roots blower deals with the petrol-air mixture. With a bore of 93.5 mm. and 114 mm. stroke the engine gave 50 b.h.p. at 1,250 r.p.m. As the N.E.C. weighed only 150 lb. the attractive figure (for 1911) of 3 lb. weight per h.p. was obtained—a very creditable achievement.

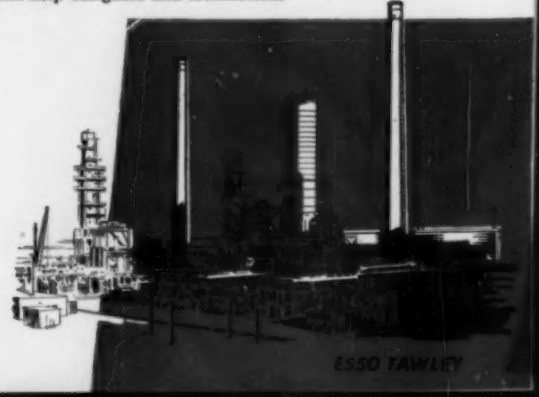
Once in a while new concepts in the design of aero-engines revolutionize traditional thinking. In the progress towards perfection the advice of Esso on all matters concerning fuels and lubricants can help designers and technicians.

It pays to consult

ESSO

ON ALL FUEL AND LUBRICATING PROBLEMS

ESSO PETROLEUM COMPANY LIMITED, 36 QUEEN ANNE'S GATE, LONDON, S.W.1.
AVIATION TECHNICAL SERVICE, RELIANCE 1261



Airliners of the World

METROPOLITAN

CONVAIR DIVISION OF GENERAL DYNAMICS CORP. SAN DIEGO, CALIFORNIA

FOLLOWING World War 2, the Convair Division of General Dynamics Corporation was one of the first organizations to offer a general-purpose airliner of then-modern conception intended for the rapidly growing network of short and medium stages. The first Convair-Liner, the CV-240, flew in prototype form on March 16, 1947, and the first certificated CV-240 was delivered to American Airlines on February 28, 1948.

Basically the 41,790-lb CV-240 had a conventional airframe, with a circular-section (usually unpressurized) fuselage of 106.5in internal diameter, a two-spar wing bearing an exceptional (for 1946) area of Fowler flap, a nosewheel undercarriage with single shock-struts carrying twin wheels, all units retracting forwards, manual flying controls by servo tabs, hot-air airframe de-icing and advanced ancillary-power systems. Unconventional features were the optional installation of a large flight of passenger stairs under the rear fuselage, facing aft, and thrust-augmentation by using the exhaust to inject cooling air over the two Pratt and Whitney Double Wasp CA18 engines and discharging air and exhaust through double propelling nozzles behind each nacelle, over the trailing edge.

When it went into service the 240 set a new standard of workaday air-transport at cruising speeds which almost met the claimed figure of 300 m.p.h. As far as can be determined the following are the present operators of the CV-240; Aerolineas Argentinas, 4; American Airlines, 75 (originally 79); Canadian Pacific, 5; Continental, 5; Ethiopian, 2; Garuda Indonesian, 8; K.L.M., 7; L.A.I., 5; Mohawk, 3; Northeast, 6; Orient, 3; PanAm, 5; Sabena, 5; Swissair, 7; T.A.A., 5; Varig, 5; and Western, 9. It is nostalgic to note that in June 1948 we recorded Convair's decision to "raise the price to approximately £100,000."

In October 1951 the prototype CV-340 first flew. This model was produced by a direct "stretch"; the fuselage was pulled out by 16in forward of the wing and 38in behind, raising the standard seating from ten rows of four to eleven rows; the wing was markedly increased in span, from 91ft 9in to 105ft 4in; and series CB16 engines were fitted. The maximum weight was established at 47,000 lb. The standard 340 can carry 44 passengers and baggage a stage-distance of 1,260 statute miles, with A.T.A. reserve fuel, cruising at 284 m.p.h. at 18,000ft on 1,200 b.h.p. per engine. Fuel is carried in two 72-gal integral tanks filling the inter-spar box beyond the engine nacelles (in the CV-240 each tank held 416 gal). The cabin is pressurized to a dP of 4.16 lb/sq in.

Production 340s have been delivered since March 1952. The present operators are Aeronaves de Mexico, 4; Aerovias Venezolanas, 5; Alitalia, 4; Ansett, 2; Braniff, 26; Continental, 14; Delta, 20; C.M.A., 8; Finnair, 3; Garuda Indonesian, 8; Hawaiian, 5; J.A.T., 3; K.L.M., 14; LACSA, 2; Lufthansa, 4; National, 12; Philippine, 3; REAL, 8; Saudi Arabian, 10; Cruzeiro do Sul, 4; and United, 55. In addition, some 350 military versions of the 240 and 340 have been delivered to the U.S. Air Force and Navy.

Latest, and last, of the Convair-Liner family is the CV-440, which has been named Metropolitan. It incorporates many detail engineering improvements affecting general equipment and comfort. In particular, the cabin soundproofing has been revised and enhanced and a new engine exhaust system, with a rectangular final outlet, is specified. The engine is the CB17-series Double Wasp, giving 2,500 h.p. if water-injection is fitted. The certificated weight with this engine is 49,100 lb. An optional extra, not originally available on earlier machines, is weather radar.

Certain operators are converting their present Convair-Liners to Metropolitan standard, a notable example being K.L.M. None the less, 88 new 440s have already been sold—partly owing to Convair's ability to offer early delivery. In chronological order, the following orders have been placed; REAL, 4; S.A.S., 11; Finnair, 1 (delivered February 1956); Sabena, 12; Swissair, 8 (increased to 11 in May 1956); Iberia, 5; Continental, 3 (delivered in recent weeks); National, 6; Delta 5; Eastern, 12; Braniff, 14; Alitalia, 2; and J.A.T., 1. Aircraft of 440 type have also been supplied to the U.S.A.F. (6), the R.A.A.F. (2) and business houses (3). These sales have raised the production run of the Convair-Liner family (including military variants) to more than 1,000.

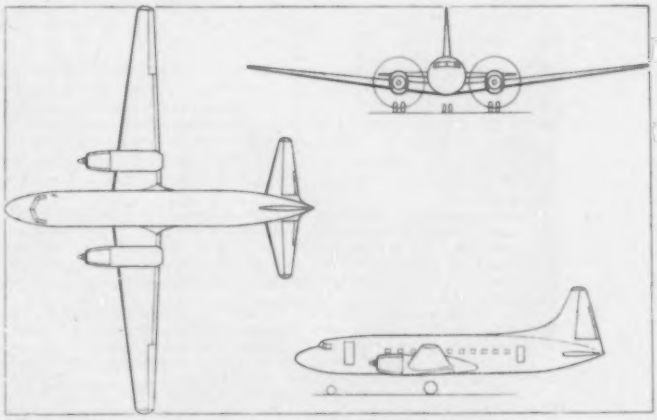
CONVAIR CV-440

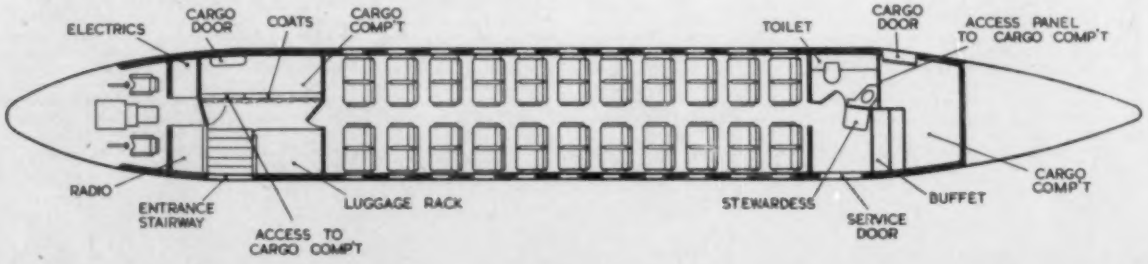
Two Pratt and Whitney R-2800 CB17 rated at 2,500 h.p.

Dimensions: span, 105ft 4in; length, 79ft 2in (81ft 6in with radome); height, 28ft 1¼in; wing area, 920 sq ft; dihedral, 6 deg 30 min; track, 25ft; wheelbase, 26ft 1¾in.

Weights: empty, 31,305 lb; max. payload, 12,880 lb (useful load, 16,695 lb); zero-fuel weight, 45,000 lb; max. landing weight, 47,650 lb; maximum weight, 49,100 lb with CB17 engines (48,000 lb with CB16 engines).

Performance: field length for take-off (see p.10): 4,930ft; rated-power climb at s.l., 1,192ft/min; mean t.a.s. at 45,000 lb at 1,200 b.h.p. with cowl-flaps closed, 289 m.p.h. at 20,000ft with consumption of 175 gal/hr; range (zero-wind) in above conditions, with 1,500 lb fuel reserve, 1,040 st.m.; stall at 46,500 lb, 85 m.p.h.; landing field length (reduced flap at 46,800 lb), 4,010ft.





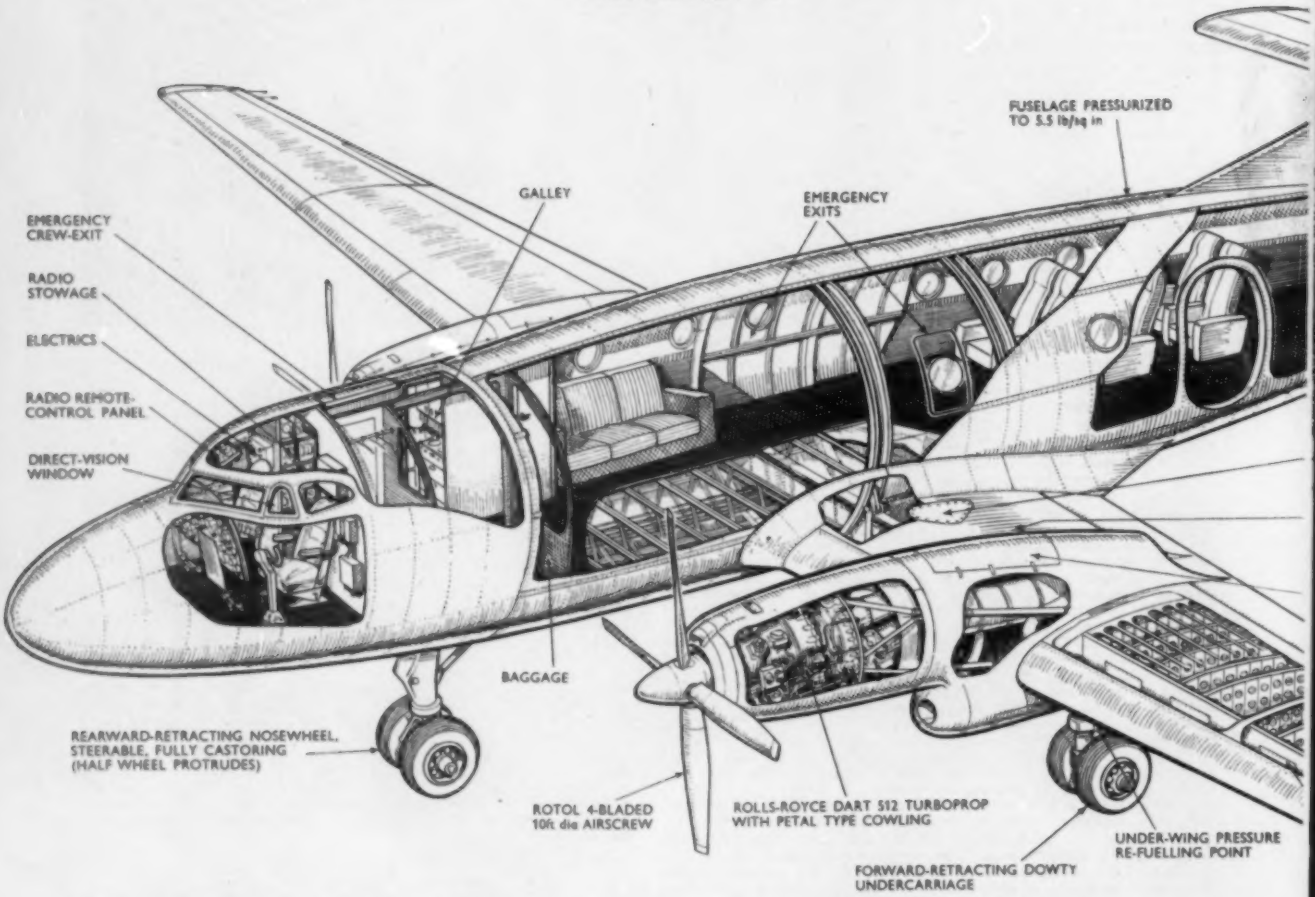
Airliners of the World

ACCOUNTANT

AVIATION TRADERS (ENGINEERING), LTD., LONDON, W.1.

Standard Mk. 1 Accountant showing forward-facing seats and inward-facing settee

Drawn at Southend, June 1956



IT was felt by Aviation Traders that, due to the diversity of rôles undertaken by the DC-3, operators' requirements would be widely divergent, to such an extent that no real conclusion could be drawn from them as to the actual specification for a replacement aircraft. The company, with its considerable operating experience, felt that it was in a good position to produce the type of aircraft most likely to fulfil the various needs of prospective operators.

Careful consideration had to be given to the obvious features which had to be retained in a successful replacement aircraft: (1) dependability and versatility; (2) a rugged structure of long life; (3) ability to load freight readily into some 1,300 cu ft of cabin space; (4) low purchase price and running costs; (5) ability to operate from short, poorly surfaced strips.

With sensible design, all these features (except price) could, it was felt, be reproduced in a new design, together with a great many additional advantages, including a higher standard of safety.

The Aviation Traders design philosophy, accordingly, was to produce an aircraft based on the following criteria.

Size and weight would be substantially similar to the DC-3. Rolls-Royce Dart turbines would be used with standard accessories and equipment. (The wisdom of this early decision, with Viscounts now ordered by more than 30 airlines, became strongly apparent.) The airframe must be simple and rugged, designed on "fail-safe" principles to ensure long life. The aircraft must be flexible in operation, capable of accommodating a satisfactory payload over short distances, and provision must be made for sufficient fuel for stage lengths up to 2,000 miles. Considerable improvements in overall performance must be provided over a wider range of payload and stage-length in any condition of temperature and altitude. The aircraft must be designed to enable increasing engine powers to be easily accommodated.

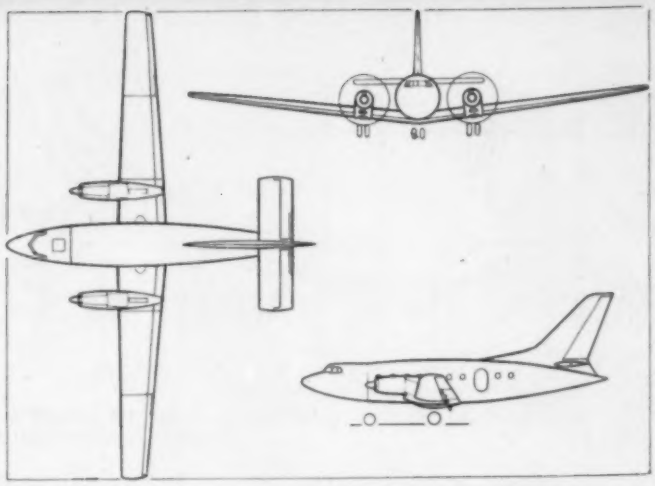
In particular, the interior layout must be designed from the start to permit the greatest possible variation of operational rôle. The Accountant can in fact be supplied with or without nose cargo-doors for, respectively, all-freight or all-passenger work; the interior lends itself well to mixed cargo-passenger operations, and furthermore has singular appeal in an executive rôle from the points of view of size and comfort.

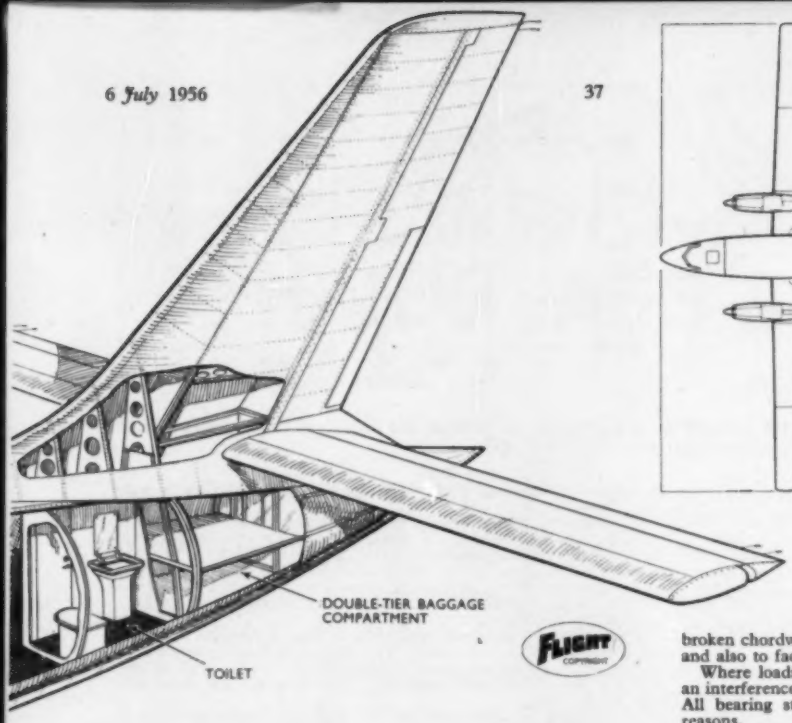
The Accountant is offered in Mk. 1 or Mk. 2 form. The Mk. 1 is normally supplied in the bare condition to enable operators to equip the aircraft to their specific requirements. The Mk. 2 can be supplied with the hinging nose or the forward freight-loading door as required. This version is 10ft longer than the Mk. 1, having a cabin volume of 1,698 cu ft compared with 1,275 cu ft. There is no significant difference in performance between the two marks. Design work on the foregoing principles has now been virtually completed, and construction is well advanced, toward a prototype first-flight at the end of this year.

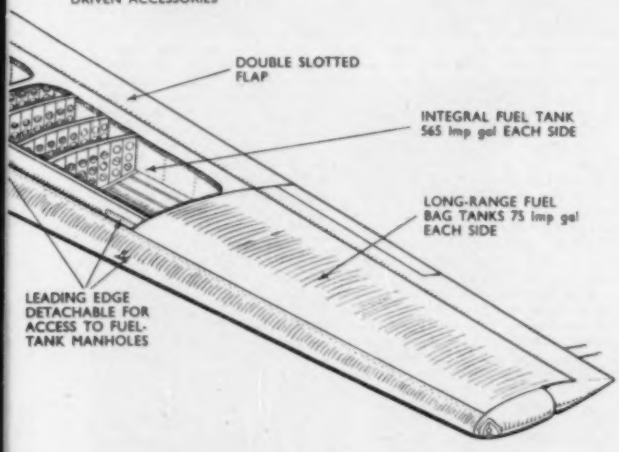
AIRFRAME. A structural break-down is employed which assists the sub-contracting of major components. The simple form of jigging required by the Heal method of construction, which provides a modest degree of tension up to 5,000 lb/sq in, confers numerous benefits to construction and appearance.

The problem of fatigue has been given primary consideration in the design of the Accountant's airframe. It was realized from the very beginning that if the aircraft was to have the economic life expected of a DC-3 replacement, great care must be exercised in the design of the pressure cabin, wing and control surfaces. A design policy of "fail-safe" on all components was adopted, the aim being that, should fatigue troubles start, they would remain localized and be readily found at normal inspections, and repaired in the usual manner. The following points about airframe design are worth noting.

The general membrane stresses of the pressure cabin have been kept down to about 12,000 lb/sq in, and attention has been paid to the design of the closely spaced radial formers to ensure continuity and freedom from notch effects. A minimum factor of 3.0 has been applied to






DOUBLE SLOTTED FLAP
INTEGRAL FUEL TANK 565 Imp gal EACH SIDE
LONG-RANGE FUEL BAG TANKS 75 Imp gal EACH SIDE
LEADING EDGE DETACHABLE FOR ACCESS TO FUEL-TANK MANHOLES

tensile stresses in the regions of cut-outs and discontinuities, and all double cabin window assemblies are clamped in position to allow differential movement between the transparency and the surrounding structure.

The entire bottom wing surface tensile material is free from cut-outs. Only single heat-treated L72 and L64 is used, and the stress level under ultimate loads has been kept low consistent with latest available S/N curves for well designed joints to ensure long life. Appropriate chord-wise joints are designed so that the end load-carrying joint-plates are broken chordwise every few inches to isolate cracking, should it occur, and also to facilitate individual inspection.

Where loads are carried through concentrated pins, these are made an interference fit by the use of split-tapered bushes to prevent fretting. All bearing stresses have been deliberately kept low for the same reasons.

The fuselage structure, pressurized to 5.50 lb/sq in (8,000ft at 25,000ft), is constructed as two separate components, the front fuselage housing crew, radio, electrical panels and so forth, and the rear main cabin housing the payload.

The wing box structure is comprised of five separate sections, the centre-section incorporating the engine installations, two semi-integral tanks each of 565 Imp gal capacity, and the outer wings with provision in each for an additional 75 Imp gal.

An extensive static and fatigue-test programme has been agreed with the A.R.B., and the second fuselage and centre-section wing will be subjected to combined pressure cycles and tail-unit gust loads representing a typical flight pattern in the R.A.E. water tank. This will be followed by a combined pressure and lateral gust high proof-test in the tank, and later the usual static ground tests will be carried out in the company's test frame.

The second wing will be subjected initially to a combined repeat flight-load and integral fuel tank pressure-test to check tank sealing under load, to be followed by static tests. Critical wing joint specimens will also be subjected to fatigue tests.

The tricycle undercarriage is manufactured by Dowty Equipment, and takes the form of short sturdy units free from the effects of dynamic springback. Twin wheels and low-pressure tubeless tyres are fitted to both the main and nose legs. The undercarriage is hydraulically actuated, the down-locks of both the main and nose gear being of the internal type; when the undercarriage is extended, the jacks act as drag struts. The up-locks are external.

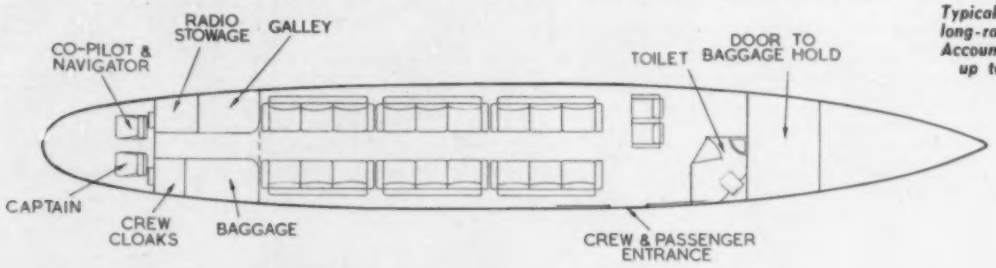
POWERPLANT. The Rolls-Royce Dart RDa.6 Mark 512 engines each give 1,730 e.h.p. for take-off. As indicated under the Weights and Performance table, this may be increased on production aircraft.

Four-bladed 10ft airscrews are fitted, of either Rotol or de Havilland manufacture, and a synchronization system is available. In the main, the installation is basically similar to that of the Viscount and every endeavour has been made to maintain a high interchangeability standard between aircraft. Fire precautions, fire access and blow-out panels, ventilation of zones, control runs, shrouds, jet pipe and cowling design have all been developed with the assistance of Rolls-Royce.

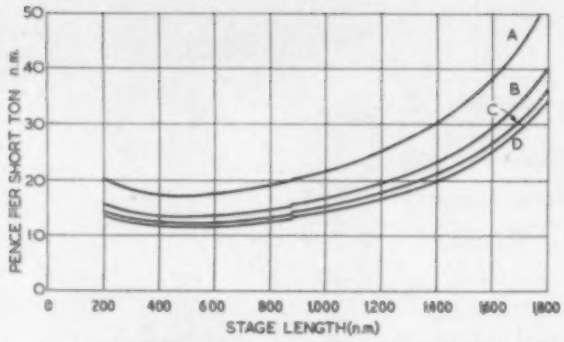
To provide maximum access for servicing, petal-type cowlings are fitted. By releasing a minimum number of toggle fasteners, the cowling can be opened up completely back to the fireproof bulkhead at the rear of Zone 2. The accessory gearbox driving the alternator, generator, cabin supercharger, hydraulic pump and tacho-generator is readily accessible by removing the access panel on the top of the nacelle in Zone 3. Access to the de-icing heat exchanger and jet pipe in Zone 3 is achieved by removing the rear nacelle fairing, which is attached by quick-release fasteners. When this is removed, the complete jet pipe and heat exchanger installation is exposed for service and maintenance or removal.

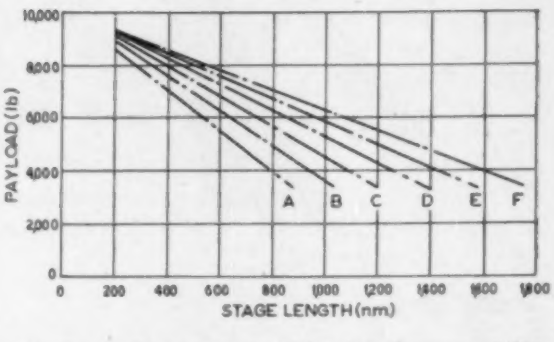
Engine controls are of the push-pull type; all control rods are adjustable for length with indexed lever positions, and provide a rigid control system free from lost movement.

An investigation into the effect on performances of fitting RDa.7



Typical layout for a long-range executive Accountant providing for up to eight berths.





In the cost curves (left) the letters A to D signify 1,000 to 4,000 hr utilization; in the payload plot (right) A to F represent 5,000ft increments in cruise height from 5,000 to 30,000ft.

Airliners of the World

ACCOUNTANT

engines shows that considerable gains are to be expected; cruising speed, for example, would be increased by 26 kt, and take-off reduced by 270ft.

SYSTEMS. Cabin Air. Fresh air is supplied at a maximum differential of 5½ lb/sq in by two superchargers, one being driven by each of the auxiliary gearboxes, giving 8,000ft cabin conditions at an altitude of 25,000ft. The air is then distributed throughout the cabin and discharged through duplicated discharge valves, no air whatever being re-circulated. Cabin rates of climb and descent are automatically controlled.

Pneumatically operated cabin temperature-control is fitted. Temperature selection is manually controlled from the cockpit; once selected, the temperature is automatically maintained.

To avoid high cabin temperatures whilst the aircraft is at rest or taxying, a simple circulation system is employed giving a supply of filtered air to occupants.

Electric. The electrical system consists of a 28-volt D.C. earth-return system supplied by two D.C. generators, automatically regulated to give 28 ± ½ volts and paralleled at the busbar. One generator is driven from each engine auxiliary gearbox. Four 24-volt 25 amp-hr batteries are fitted and connected to the busbar *via* circuit-breakers operated from a battery master switch. The batteries can be used for engine starting when no external ground supply is available and they are so arranged that in an emergency a source of D.C. power is available.

Three 115-volt 400-cycle rotary inverters provide power for flight instruments, autopilot and V.O.R./I.L.S. To provide an alternative source of power for flight instruments, change-over switching is used for the autopilot and flight-instrument inverters.

Two 208-volt alternators are fitted, one driven from each engine auxiliary gearbox, and these provide power for de-icing the engine air intakes and airscrews. Each engine air intake and airscrew is supplied from its own alternator and the loads are cycled *via* a time switch.

Hydraulic System. The working pressure of the hydraulic system is 3,000 lb/sq in, and the fluid employed is DTD 585. Power is supplied by two Lockheed Mk. 7 pumps, one driven by each of the auxiliary gearboxes. A hand-pump is also fitted, mainly for ground use, but it may be used to operate any service in flight. Ground-test connections, with self-sealing couplings, are provided in the leading edge of the port wing.

Four accumulators are fitted: one for the normal system, feeding any service; two others provide separate sources of power for the wheel-brakes, and the fourth provides power for emergency lowering of the undercarriage. There is a single air-charging point for the accumulators.

Wing flaps are operated by two jacks, one in each wing. A secondary flap-lowering system is provided in the charge of the solenoid-operated selectors by which flaps may be lowered with the hand-pump. On selection of "emergency flaps down," the hand pump is isolated from the main system and connected directly to the flap emergency system. Similarly, the hand-pump lowers the undercarriage should the normal emergency system fail.

The nosewheel steering is of Dowty design and is controlled manually by a tiller operated by the pilot's left hand. An automatic centring jack is provided.

Toe-operated disc brakes and anti-skid equipment are standard. These may be of either Dunlop or Goodyear design depending upon customers' requirements. Emergency braking is accomplished by a hand lever which also acts as a parking brake. No differential braking is available on the emergency brake-parking system, which is independent of the normal toe-operated braking system.

The main wheels are automatically braked on selection of "undercarriage up," and will have stopped revolving before the undercarriage begins to retract. Complete retraction time is less than five seconds.

There are no high pressure hydraulic lines routed within the pressurized fuselage.

Fuel. The fuel system has been kept as simple as possible. Basically, each of two semi-integral tanks (565 Imp gal each) feeds its own engine. A cross-feed line ensures that fuel can be fed from either tank to either engine. Provision is made for additional tankage in the outer wing for special long-range requirements.

Refuelling can be either by pressure through the refuelling valves, or by gravity through an overwing refuelling cap. Smith's Waymouth gauges are employed for contents indication. This system is employed also to establish the amount of fuel fed into the tanks by the refueller. Fuel capacity can also be checked by dipsticks.

A booster pump is installed on each spar in specially designed pump compartments designed to enable pumps to be changed without draining off fuel.

A thick wing section permits generous access in the front spar for servicing and maintaining the tanks, it being possible for a man to enter the tank and to reach all parts of it without difficulty.

Provision is made for a water/methanol system to restore engine power for take-off in elevated temperatures. The tank capacity of 32½ Imp gal is sufficient for six minutes at take-off power in I.S.A. +30 deg C conditions.

Flight Deck. The crew compartment forward of the radio station has adequate head-room and width. The windscreen incorporates a direct vision panel which slides back to give the pilot a wide angle of clear vision straight ahead and rearwards. Both wing tips are visible from either pilot's seat.

The glazing of the windscreen has a dry-air heated sandwich for bird-proofing, de-misting and de-frosting. Anti-icing spray equipment may be fitted if required.

Flying Controls. These are of normal design, the dual control columns being of the cranked type so that there is ample room for the pilots' legs and easy access to the seats. The rudder pedals give a natural foot movement to ensure ease of operation of the toe-operated brakes. Liberal adjustment is provided to cater for length of leg. The main engine controls are grouped on the central console directly below the engine instrument panel, and are easily accessible to both pilots. The undercarriage and flap selector also are grouped on the console, together with the trim controls. The main flight panel consists of the usual instrumentation and is laid out to conform to accepted modern standards. The controls for the radio and navigational aids are grouped on the cockpit roof between the pilots.

Radio. The radio station is on the starboard side of the aircraft between the cockpit and the main cabin. A typical complete radio installation, variable according to requirements, is as follows: dual V.H.F. transmitter-receiver; H.F. transmitter-receiver; M.F. receiver; A.D.F.; I.L.S./V.O.R. receivers; intercommunication equipment. Provision is also made for the Decca Navigator and a flight director system. With the exception of H.F. and A.D.F., all aerials are of the suppressed type. The V.H.F. fan aerial is mounted in the fin, and the glide path, localizer and V.O.R. are slot type aerials mounted in the nose. The A.D.F. loop is housed on top of the fuselage and the I.L.S. marker is situated in the front fuselage bottom surface forward of the pilots. A "towel-rail" is provided for the A.D.F., and the H.F. aerial is of the normal wire type mounted between fin and forward fuselage.

PAYLOAD ACCOMMODATION. The Accountant has been designed to cater for a variety of operational rôles. Every airliner is adaptable to some extent; the Accountant has been designed from the start to give the operator the widest freedom of choice. Examples of the various versions are as follows: (1) Executive aircraft, for ranges up to 2,000 nautical miles, seating up to 18 passengers in luxury seats and with sleeping accommodation for 6 to 9 with bar facilities if required. (2) High-density 42-passenger version (Mark 2) with built-in airstairs. (3) Mixed freight and passenger version, separated by a movable bulkhead. (4) All-freight aircraft, using the full cabin capacity of 1,695 cu ft and nose cargo-doors.

In addition the Accountant is offered as an ambulance, and as a high altitude (30,000ft) photographic survey aircraft equipped for low level geological survey with a magnetometer installation.

AVIATION TRADERS ACCOUNTANT

Dimensions: Overall length, 60ft 6in (Mk 1), 70ft 6in (Mk 2); wing span, 82ft 6in; gross wing area, 632 sq ft; aspect ratio, 10.77; height overall, 24ft 7in.

Weights and performance, I.S.A., Dart Mk 512 engines.* Gross weight, 28,500 lb (Mks 1 and 2); maximum landing weight, 27,000 lb (Mks 1 and 2); zero fuel weight, 26,500 lb (Mks 1 and 2); basic operational weight, 15,650 lb (Mk 1), 16,510 lb (Mk 2); internal fuel capacity, 1,280 Imp gal (Mks 1 and 2); capacity payload, 6,000 lb (Mk 1), 8,400 lb (Mk 2); fuel and payload, 12,400 lb (Mk 1), 11,600 lb (Mk 2), 12,850 lb (freighter).

Mean cruising speed, 25,000ft, 13,600 r.p.m., 256 kt; rate of climb, two engines, sea level, 1,500ft/min; stalling speed, flaps down, 26,000 lb, 64.3 kt, E.A.S.; take-off distance† to 50ft, two engines, sea level, civil technique, 2,740ft; B.C.A.R. take-off field length, one engine out, sea level, 3,120ft; landing distance from 50ft, sea level, 2,054ft; B.C.A.R. landing field length, 2,930ft.

* A recent investigation by Rolls-Royce has indicated that the RDa.6 engines, designated Dart 512 for initial Accountant production, will, when fitted with increased diameter jet pipes, give an increase in power at cruising speeds with a reduction in specific fuel consumption of some 4 to 5 per cent. The exact effect of this in the Accountant's performance is not yet known, and the figures given are for the aircraft fitted with standard jet pipes. The effect of fitting the more powerful RDa.7 is briefly discussed under "Powerplant."

† Water-methanol is used to restore take-off power in temperatures above I.S.A.

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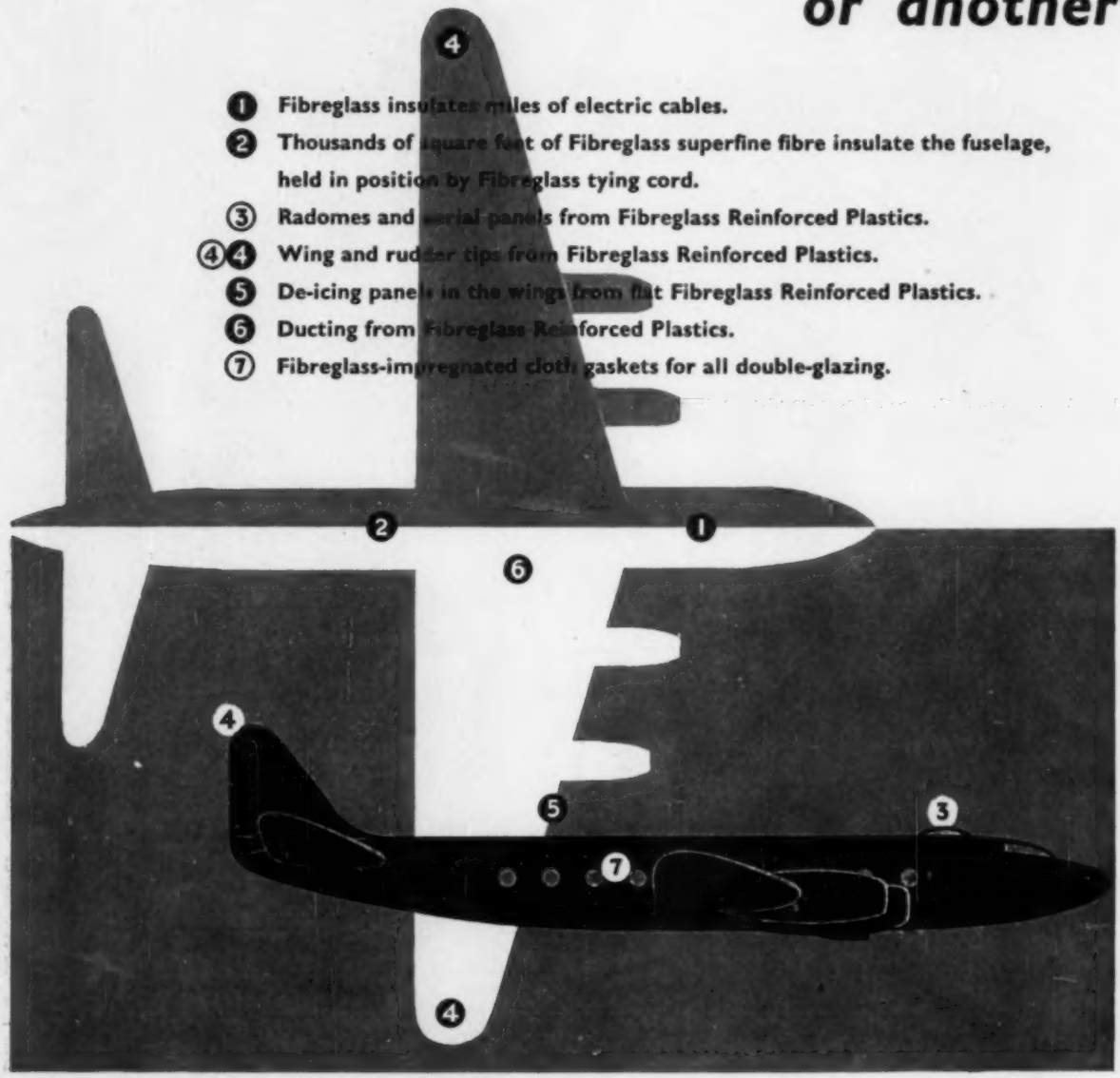

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Shown at Dublin Airport is an Aer Lingus Viscount displaying the company's new colours of dark green on top of a broad white fuselage flash. Cellon finishes were chosen for the colour scheme because they have a distinctive appearance and are outstandingly durable and inexpensive to maintain. These were three essential factors that Aer Lingus needed to consider since their aircraft largely operate into industrial areas where a natural finish is both difficult and costly to maintain.

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Airliners of the World

ELECTRA

LOCKHEED AIRCRAFT CORPORATION, BURBANK, CALIFORNIA

FOR many years the Lockheed Aircraft Corporation have wished to develop a "new-generation" transport but have not known whether to go for the jet or the turboprop. Since 1954 their widespread experience with the latter form of powerplant and, in particular, their production contract for the C-130 military transport with four Allison T56 engines, encouraged them to develop what seems to them to be the best sort of four-turboprop liner for the widest possible market. This has materialized as the Model 188 Electra.

It is a design which, although superficially conventional, has many unusual constructional features necessitating heavy tooling costs. In some ways it is as unlike its predecessor, the Constellation, as can be imagined, yet in details—and, in particular, in "systems"—extraordinarily close similarity is manifest everywhere. The design is still by no means finalized but the following text outlines its essentials.

AIRFRAME. As already noted, Lockheed have adopted what they consider to be the optimum structure, without regard to tooling problems; they are a company with exceptional production equipment and lengthy experience of advanced airframe techniques. Certainly no money has been spared with the Electra and Lockheed believe it will pay them in the long run in giving them an airframe of unsurpassed integrity.

Fuselage. This has a constant, circular section, reached after what must be one of the bluffest noses on any transport. The simple frames are generally spaced at 19in and comprise lipped channels alternately facing fore and aft and notched to receive the rolled-section stringers. Straps are then added around the frames on top of the stringers to form an unbroken load-path beneath the skin. The frames are not continuous hoops; from station 200 (the production break just behind the flight deck) to 1,118 (the rear pressure bulkhead) the fuselage is a cylinder formed from four quarter-sections (top, bottom and two sides), the floor beams joining the bottoms of the side members.

At stations 570 and 695 are strong frames, starting as I-section forgings, to which the wing spars are attached. Skin is applied in large panels the full depth of each quarter-fuselage panel. The front pressure bulkhead is a kinked and braced disc, whereas the rear pressure-dome is convex. The tail-cone is joined around the periphery of the pressure bulkhead and provides structural continuity for the fin; fuselage/empennage fillets are part of the fuselage skin, all joints with the tail surfaces being outboard of the fillets.

The main entrance door pulls inwards and then slides into the roof leaving a space through which a stairway with 13 steps can be lowered. Windows are double sandwiches with the primary load-carrying panels protected from damage. Of rectangular shape with rounded corners, and measuring 16in (width) × 18in, they are spaced at alternate frames (and in the large drawing do not coincide with the seat pitch). Four above the wing can be pulled inwards to leave exits 19in × 28in. Two freight holds are provided under the floor with the power services outboard of the vertical floor-support pillars. The doors of the holds will either push in and slide or be hinged along their upper edges. One operator has requested provision for pre-loaded baggage containers, which presents a difficult design job for apertures, winches and rails.

Wing. The left and right mainplanes are bolted to a central carry-through structure extending just beyond the fuselage frames. There are two spars with wide chordal spacing; the front spar is straight and perpendicular to the longitudinal axis and the rear spar is swept forward with a kink at the aileron. The webs are longitudinally split into upper and lower portions joined by a double row of rivets to provide a fail-safe characteristic. Extruded booms are riveted on, as are multiple, vertical angle-stiffeners; studies have also been made with machined webs incorporating flanges, without separate booms. The closely spaced ribs are lattice girders fabricated from angle sections, with a peripheral member notched to receive the stiffeners of the integral skins.

The upper and lower surfaces between the spars are formed from machined planks, each with about six spanwise stiffening webs. The panels extend from root to tip with a width of about 20in; they are secured by double rivet rows at lap-joints to preserve the integrity of the wing box should one panel crack. There are three full-span panels above and below the wing parallel to the front spar, extra panels being brought in to fill the chordwise spread of the spars towards the root. Design tensile stresses in the lower-surface panels are exceptionally low.

Between the engines and inboard of the inner engines the leading-edge sub-structure hinges downwards from the bottom of the front spar to provide access to the interior systems (such as cabin and de-icing air). Behind the rear spar is a secondary structure forming the flap shrouds, comprising a continuous outer skin and a bonded inner skin with multiple cut-outs and stiffening joggles. The tip assemblies incorporate three small spanwise members attached to the tank end-ribs on station 567.

Tail. Behind the rear pressure bulkhead the Electra is the responsibility of Northrop Aircraft, Inc., who will manufacture the empennage under sub-contract. The fin has two main spars growing integrally from the fuselage frames, the front spar rising vertically for 6ft from station 1,168 and then sweeping backwards. The rear spar and the triple stiffening angles are truly vertical, the structure being completed by multiple braced ribs with flanged lightening holes. Each fin-skin incorporates a structural-plastic V.O.R. window near the top and the leading edge carries an electric de-icer. The rudder is hung on four hinges and has a mass-balance along the leading edge. It is a simple assembly with sheet ribs and a stiffened skin.

Each half tailplane is bolted to a short centre-section integral with the fuselage and picking up on two frames. The two principal spars are at 19 per cent chord and the trailing edge, and the ribs are lattice girders as in the wing. On the ribs are located heavy extruded stringers to which the skin is attached. The elevators are each hung on five hinges and have horn balances.

Undercarriage. Designed and manufactured by Menasco, the Electra gear looks neat and sturdy although its shortness brings the inner airscrews within 17in of the ground. Each main leg is a single forging with a massive cross-piece, braced to the leg by tubes, forming a wide yoke at the top. This yoke is carried outside the integral wing-box on trunnions bolted to the lower periphery of two very large forged truss-ribs slightly farther apart than the width of the inboard nacelles. The leg is braced from the bottom boom of the front spar by a drag member, which acts as a nutcracker broken by two small jacks. The gear is pushed forwards by a single hydraulic jack acting directly on the top of the main leg. The twin wheels on each leg embody anti-skid brakes and the tyre pressure varies according to weight and c.g. between 125 and 138 lb/sq in, giving an isolated wheel load of 23,000 to 26,800 lb. Each wheel-bay has four large doors.

The nose leg is of similar geometry in being a T-forging and it is hinged to a pair of forged Warren girders—with a length of at least 8ft—beneath the cockpit. The twin nosewheels can be steered through ±60 deg to pivot the aircraft about either main leg. The unit is pulled forwards by a hydraulic jack into an unpressurized box with twin doors which remain open on the ground.

Flying Controls. All the Electra's flying-control surfaces are driven through duplicated hydraulic boosters (manual stand-by) of Eclipse-Pioneer manufacture. These are neat assemblies on a forged frame, almost identical with those on the C-130 and L.1649. Cables from the flight-deck, or electric signals from the autopilot, operate electric-hydraulic valves to modulate the booster cylinders. All three boosters are almost identical. Those for the rudder and elevators are hung side-by-side from beneath the centre tailplane section within the tail-cone, where they are controlled by an under-floor cable system and drive their respective surfaces through very short linkages.

Each aileron is hung from the upper edge of its front spar with multiple mass-balance portions along its leading edge. The aileron booster is mounted in the fuselage on the rear face of the rear spar, where it is controlled from the cockpit through cables running under

Airliners of the World

ELECTRA

the floor and over the top of the centre-section. The booster operates port and starboard push-pull rods running straight along the back of the wing box to the tail of the outer nacelles, where they kink rearwards and finally drive the undersides of the ailerons through bell-cranks. Single cables transmit the manual aileron trim. Each cable bifurcates to drive duplicated screw-jacks attached to the tabs.

Under the fuselage is a speed brake consisting of three panels hinged beneath the wing trailing edge which close flush with the fuselage skin. All three are driven by a single hydraulic motor in the starboard fillet *via* torque shafts, bevel gears and screw-jacks. The brakes can be pushed open with the flaps or independently.

Each mainplane carries a single section of Fowler flap running on multiple roller carriages in five steel tracks. Operating power is supplied by duplicated hydraulic motors mounted inboard and driving through torque-tubes and triple-extension, ball-bearing screw-jacks. There are two jacks to each flap section, attached to the rear face of the rear spar adjacent to the upper boom and passing through the single spar of the flap to pick up between adjacent strengthened plate ribs. As the flaps are pushed down the tracks their angle of incidence steadily increases until the roller-carriages hit "quick cams" at the far end, which suddenly depress the flaps to about 70 deg at full extension. Flaps and ailerons are the responsibility of Temco.

POWERPLANT. Although such engines as the Rolls-Royce Tyne are obviously suitable and are being studied by Lockheed, the Electra was designed around the Allison 501-D13. This engine is rated at 3,740 e.h.p. (3,460 s.h.p.) for take-off; a typical cruising rating is 1,850 s.h.p. at 25,000ft. It is a single-shaft turboprop with a pressure ratio of 9 : 1, a cannular combustor and a four-stage turbine. The reduction gear is mounted ahead of, and beneath, the remainder of the engine, driven by a shaft embodying a torquemeter.

The standard airscrew is an Aeroproducts four-blade unit of 13ft 6in diameter, with take-off autofeathering, reverse pitch and provision for automatically increasing blade angle upon receipt of reverse-torque signals. Electras for K.L.M. will have an advanced airscrew by Hamilton Standard.

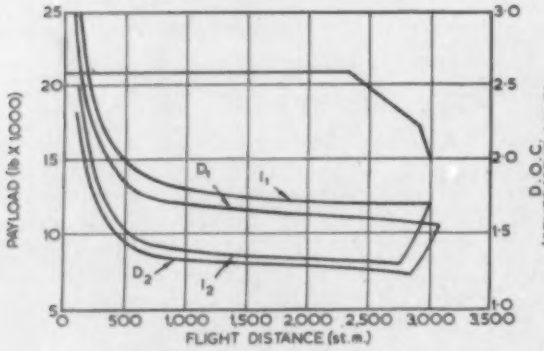
Each powerplant is supplied as a "quick engine-change" unit complete with airscrew; Rohr Aircraft will manufacture the complete installations, including nacelles and tailpipes. The engine itself is hung from a ring on the firewall bulkhead with a steady at the turbine section. Extensions from the front of the wing box form the roof of the undercarriage bay and also carry most of the engine loads. Airscrew thrust and torque are reacted through steel-tube trusses attached at four points to the main firewall, the two principal members being continued on each side of the engine to the second firewall and then being inclined down to anchors above the wing-box above the undercarriage girder-ribs

The tailpipe is passed back across the wing to a propelling nozzle above the trailing edge. Each pipe lies in a stainless-steel trough supported by transverse trunnions. The oil tanks are mounted immediately above each engine, and a drum-type oil cooler is mounted in the lower part of each cowling, with a ram intake beneath the spinner. Accessories are driven from the reduction gear-box and each nacelle is divided into three fire-zones separated by firewalls, with appropriate fire surveillance and high-rate extinguishing systems. Large hinged panels on each side provide access to the gear-box, engine and accessories and further panels admit to the hot parts of the engine and tailpipe. A considerable proportion of the skin is titanium.

Although certain operators may specify a different system, the standard starting arrangement features a fuel/air combustion starter on each engine. Air for this purpose is stored in 3,000 lb/sq in bottles behind the firewall in the outboard nacelles. The system incorporates combustors, fuel pumps and igniters which raise the temperature to 1,000 deg F and take the engine to 8,240 r.p.m. before cutting out after 12 sec. During flight the air bottles are recharged (from the pressure remaining after one start) in 16½ min. Air is supplied by a six-cylinder radial compressor in the rear of each inboard nacelle driven by a hydraulic motor from the undercarriage circuit.

One of the drawbacks of the D13 engine is its high rotational speed of 13,820 r.p.m. under all flight conditions. Strenuous efforts are turning it into a satisfactory commercial engine and Allison, who have never powered commercial aircraft before, are pursuing an aggressive sales policy. The approved overhaul life is hoped to reach 625 hr in 1958, with 1,000 hr scheduled for 1959. In the latter year the refined 501-D15 unit—to which D13s can be converted—will deliver 4,050 e.h.p. and the Electra is structurally and aerodynamically capable of using the very advanced Allison 550, of 5,500 e.h.p., which should be cleared by 1960.

The upper curve shows the capacity payload for the Electra before the recent increase in authorized weight to 113,000 lb. The lower curves show operating cost for 66-seat domestic and international versions (D_1 and I_1) and 80-seat versions (D_2 and I_2).



SYSTEMS. Cabin Air. Positive-displacement blowers are mounted on the reduction gearboxes of both inner engines, each feeding air at the rate of 55 lb/min. The air ducts pass along the leading edge of the wing and enter an air-conditioning bay in the fuselage at station 502, in which the equipment is centralized. Two air-cycle coolers are mounted to port with the fans on top; to starboard is a self-contained Freon system for ground-cooling, energized by the main engines or by electric power. A single hatch in the underside of the fuselage provides access to the bay for a man standing on the ground. N.A.C.A. intakes for the inter-coolers are provided on each side of the fuselage adjacent to the air-conditioning bay, from which the air is dumped overboard through the bottom skin.

It is probable that the air will be taken into the fuselage beneath the baggage racks and extracted along the port and starboard sides of the roof. The walls are heated by the incoming air, and the floors are also heated, although in certain areas this is likely to be electric. The rear pressure bulkhead carries an inwards-relief valve at the centre with dual outwards-relief valves above. Beneath the port side of the floor at station 250 is a separate heater, fan and filter system serving the flight deck.

Fuel. A simple four-tank system is provided with automatic trimming and cross-feed. All tankage is integral between the widely spread wing spars. The inboard tanks, starting at the root end-ribs, each have a capacity of 918 gal, although this could no doubt be increased if fuel were allowed to permeate the region between the undercarriage rib trusses. The outboard tanks each hold 1,324 gal and are terminated by end-ribs one station in from the tip, to which the float valves are attached. Fuel lines run within the tanks and a vent manifold and flame trap points aft at each wing-tip. Liberal inspection panels are provided in the integral under-surface. A single pressure-fuelling socket is stationed some 6ft from ground-level at the rear end of the starboard inner nacelle, and each tank has standard over-wing filler caps.

Hydraulics. Duplicated fail-safe systems operate at 3,000 lb/sq in, the two pairs of pumps being mounted one on each engine. Services include undercarriage retraction, speed brakes, flaps, wheel brakes, control boosters and folding stairway.

As an example of the duplication provided, the captain's brake pedals are in a separate system from those of the co-pilot. The hydraulic servicing bay is under the fuselage floor immediately behind the wing box with a single large access door. Within it are accommodated the aileron booster unit, the brake accumulator, emergency air-sphere for braking, and centralized shuttle valves; the reservoirs, of unequal size, are mounted at station 749.

Electrics. Each engine reduction gearbox carries a 60 kVA alternator supplying current at 208/120 V, three-phase, 400 c.p.s., with automatic load-transfer. Priority loads can be maintained on any two alternators. All major components are centralized in a service centre beneath the floor immediately ahead of the wing. Among the principal electrical loads are those associated with ice protection.

Ice Protection. The wing and engine intakes are anti-iced by air bled directly from the Allison compressors. To reduce weight, air is extracted at high pressure and at 600 deg F and piped to the wing root along the front of the wing box. The duct then runs back inside the leading edge itself down the centre of an inner skin; along the front of the pipe small injection nozzles squirt the hot air against the inside of the skin. The air then runs back across the chord and escapes from flush exits. The system is designed to meet continuous and intermittent heavy icing.

Airscrew de-icing is electro-thermal and Nesa glass is used in the windscreen. Originally the tail was to have been de-iced by bleed air, but electro-thermal elements are now specified. Each will extend over the complete length of tailplane or fin leading edge to 15 per cent chord, the heating being cyclic (8 sec per cycle) at 19 watts/sq in.

Flight Equipment. The standardized flight deck, reached after some six years of committee meetings, follows practices recommended for the S.A.E. Type II S.7 cockpit. The operating crew comprises captain, first officer and an engineer seated behind the pedestal. Behind the captain is a seat for an observer—or, in over-water Electras, a curtained cubicle for a navigator.

Experience of the mock-up emphasizes that the flight deck is really exceptionally wide. All seats are large and adjustable and plenty of thought has been given to crew comfort and kit stowage. Basic electric panels are at the rear to starboard, with radio and electronics to port. The whole roof between the circuit-windows is occupied by a switch panel. Emergency controls can be reached by all three crew members.

Except for the duplicated H.F. and A.D.F. systems, all aerials are flush. Provision is made for weather radar beneath the hinged and heated nose radome, and other aerials include V.H.F. windows in the fin and D.M.E. on the bottom centre-line around station 274.

PAYLOAD ACCOMMODATION. From the flight deck a level floor extends to the rear pressure bulkhead at a height of 97.25in from the ground. The entrance vestibule is 38in wide, around which will normally be carry-on baggage bays, coat closets and two toilets with a water tank above the roof trim. The total usable floor area is 710 sq ft.

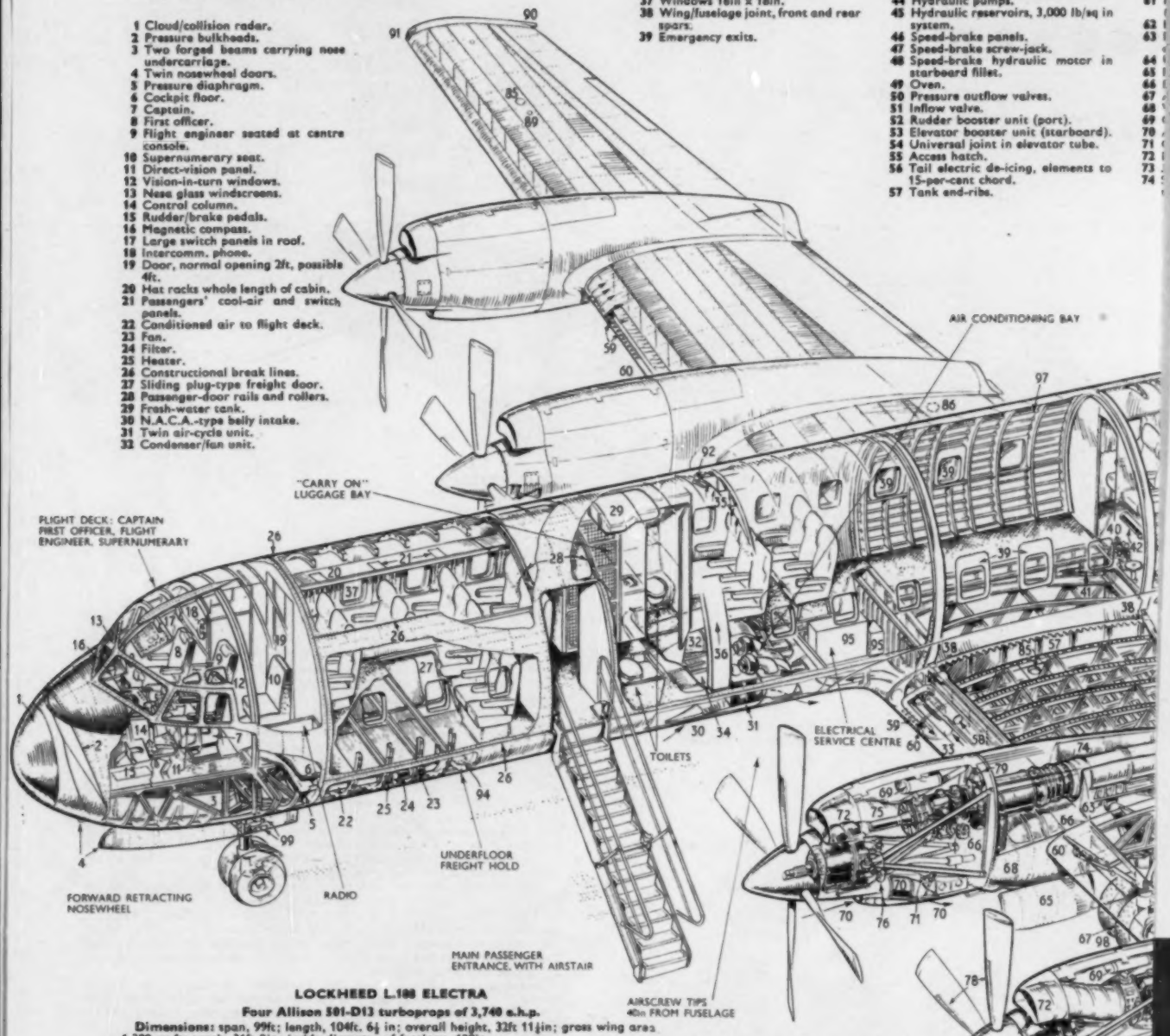
Fixed light and ventilation panels are provided under the baggage racks at 38in pitch, which will be the seat pitch in most versions. Lockheed are anxious to sell Electras with a new pattern of seat 20in between the arm rests incorporating optional seat-back tables and steps for access to the baggage racks. In an attempt to quieten the interior, no seats are fitted in the three bays adjacent to the plane of the airscrews in any version contemplated. Standard equipment includes synchro-phasing of engine r.p.m., and the clearance between the inboard discs and the fuselage is 39.7in.

Aft of station 200 is a large under-floor hold with a door on the

ELECTRA

Lockheed L.188 Electra in standard mixed-class form.
Drawn at Burbank in May 1956.

1 Cloud/collision radar.
2 Pressure bulkheads.
3 Two forged beams carrying nose undercarriage.
4 Twin nosewheel doors.
5 Pressure diaphragm.
6 Cockpit floor.
7 Captain.
8 First officer.
9 Flight engineer seated at centre console.
10 Supernumerary seat.
11 Direct-vision panel.
12 Vision-in-turn windows.
13 Nose glass windscreens.
14 Control column.
15 Rudder/brake pedals.
16 Magnetic compass.
17 Large switch panels in roof.
18 Intercomm. phone.
19 Door, normal opening 2ft, possible 4ft.
20 Hat racks whole length of cabin.
21 Passengers' cool-air and switch panels.
22 Conditioned air to flight deck.
23 Fan.
24 Filter.
25 Heater.
26 Constructional break lines.
27 Sliding plug-type freight door.
28 Passenger-door rails and rollers.
29 Fresh-water tank.
30 N.A.C.A.-type belly intake.
31 Twin air-cycle unit.
32 Condenser/fan unit.
33 Air from compressors on inboard gearboxes.
34 Central access hatch.
35 Roof ducting, air-conditioning.
36 Conditioned-air riser to 35.
37 Windows 16in x 18in.
38 Wing/fuselage joint, front and rear spars.
39 Emergency exits.
40 Aileron hydraulic booster unit on rear spar.
41 Pilot-input cables to 40.
42 Brake accumulator.
43 Emergency brake air bottle.
44 Hydraulic pumps.
45 Hydraulic reservoirs, 3,000 lb/sq in system.
46 Speed-brake panels.
47 Speed-brake screw-jack.
48 Speed-brake hydraulic motor in starboard fillet.
49 Oven.
50 Pressure outflow valves.
51 Inflow valve.
52 Rudder booster unit (port).
53 Elevator booster unit (starboard).
54 Universal joint in elevator tube.
55 Access hatch.
56 Tail electric de-icing, elements to 15-per-cent chord.
57 Tank and-ribs.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"CARRY ON" LUGGAGE BAY
FLIGHT DECK: CAPTAIN FIRST OFFICER, FLIGHT ENGINEER, SUPERNUMERARY
TOILETS
ELECTRICAL SERVICE CENTRE
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MAIN PASSENGER ENTRANCE, WITH AIRSTAIR
AIRSCREW TIPS 40in FROM FUSELAGE
ALLISON 510-D13 CONSTANT-SPEED TURBOPROPS WITH REMOTE REDUCTION GEARBOX 3,740 e.h.p. (3,460 s.h.p.)
AEROPRODUCTS AIRSCREWS 13ft 6in dia

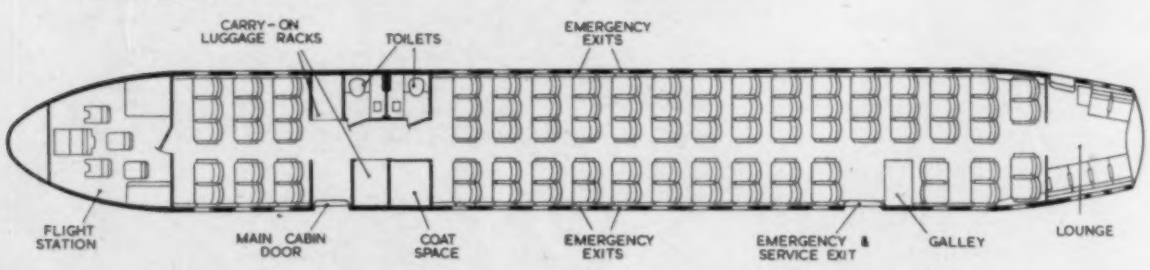
LOCKHEED L.188 ELECTRA

Four Allison 501-D13 turboprops of 3,740 e.h.p.

Dimensions: span, 99ft; length, 104ft. 6½ in; overall height, 32ft 11½in; gross wing area 1,300 sq ft; track, 31ft 2in; inside diameter of fuselage, 12ft 8in.

Weights: full figures not available, but maximum weight is 113,000 lb and max. landing weight 95,650 lb. The following is a breakdown of the weights as at April 1956: empty, 54,000 lb (55,000 international); operating weight, 57,272 lb (59,408 int.); payload, 18,000 lb (66 passengers and 7,110 lb freight and baggage); 2 hr reserve fuel 7,080 lb (7,220 int.); landing weight, 82,352 lb (84,630 int.); design gross weight, 110,000 lb; design landing weight, 93,400 lb.

Performance (estimated): not available, except the following: C.A.R. field lengths, 4,950ft (take-off) and 5,040ft (landing) for 1,500-n.m. stage, 5,740 and 5,040ft for 2,000 n.m. and 5,800 and 4,880ft for 2,500 n.m.; 5,000ft runways will be adequate for operations on 1,850-st.m. stages with full payload against a 50-m.p.h. headwind; max. range with 66 passengers and 2½ hr reserve fuel is 2,800 st.m.; normal operational climb at "normal take-off weight" at sea level is 2,400ft/min; twin-engine ceiling is 15,000ft. In April the cruising speed curve fell from 410 m.p.h. at very short stage-lengths to 400 m.p.h. at 2,500 st.m.; design limits were then: V_D, 405 kt e.a.s. below 8,000ft and V_C, 324 kt e.a.s. below 12,000ft and Mach 0.615 above.



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ELECTRA

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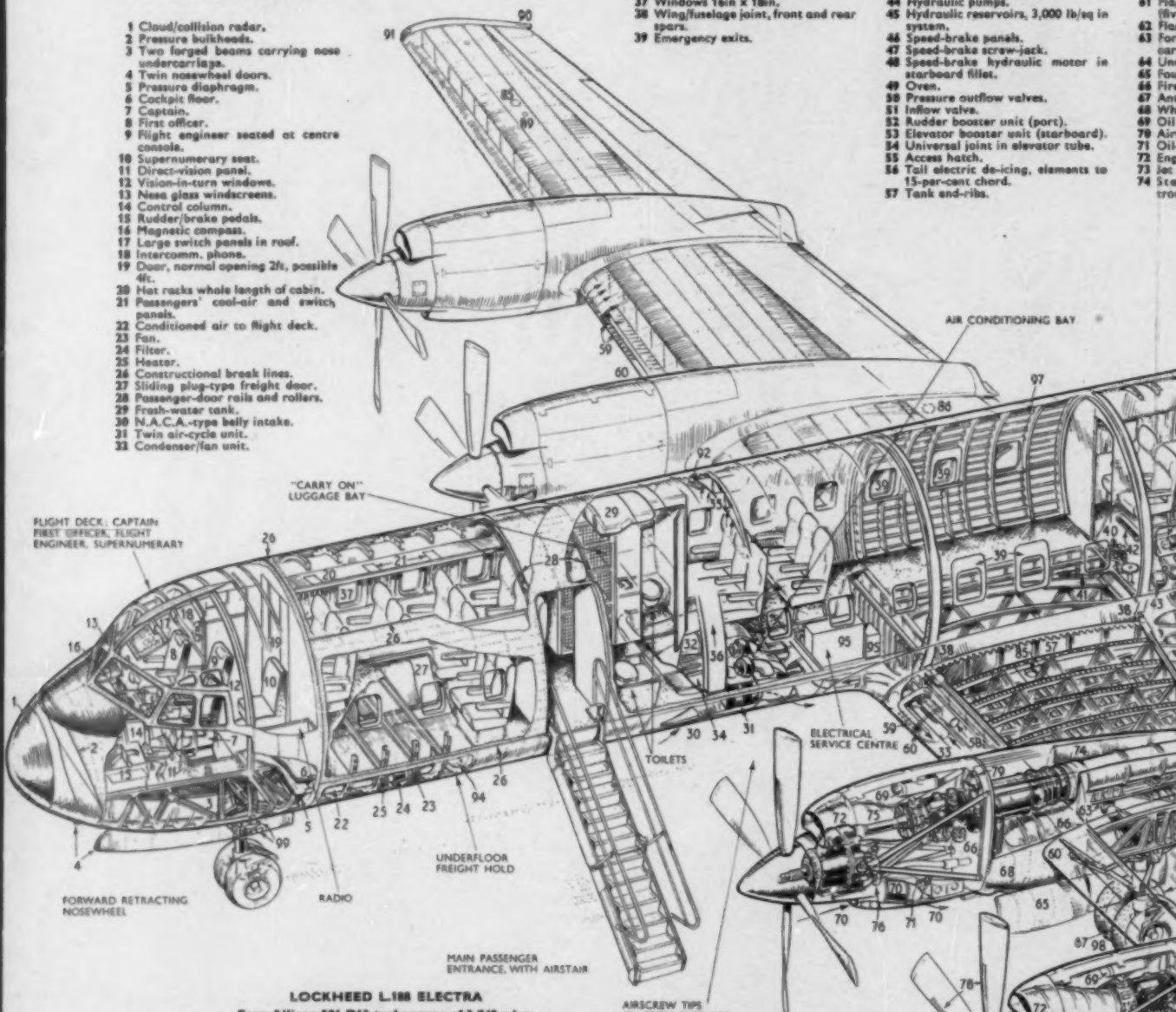
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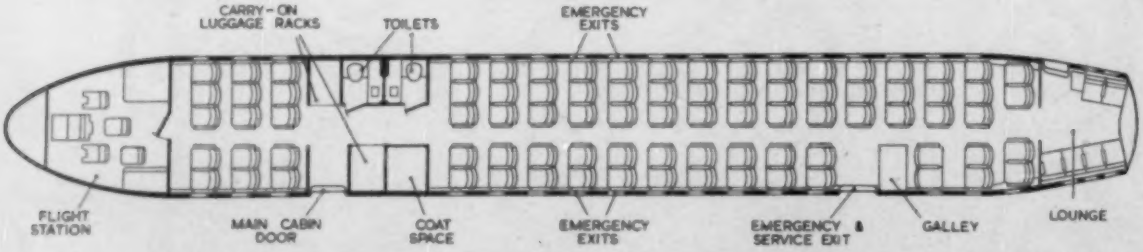

The Elect
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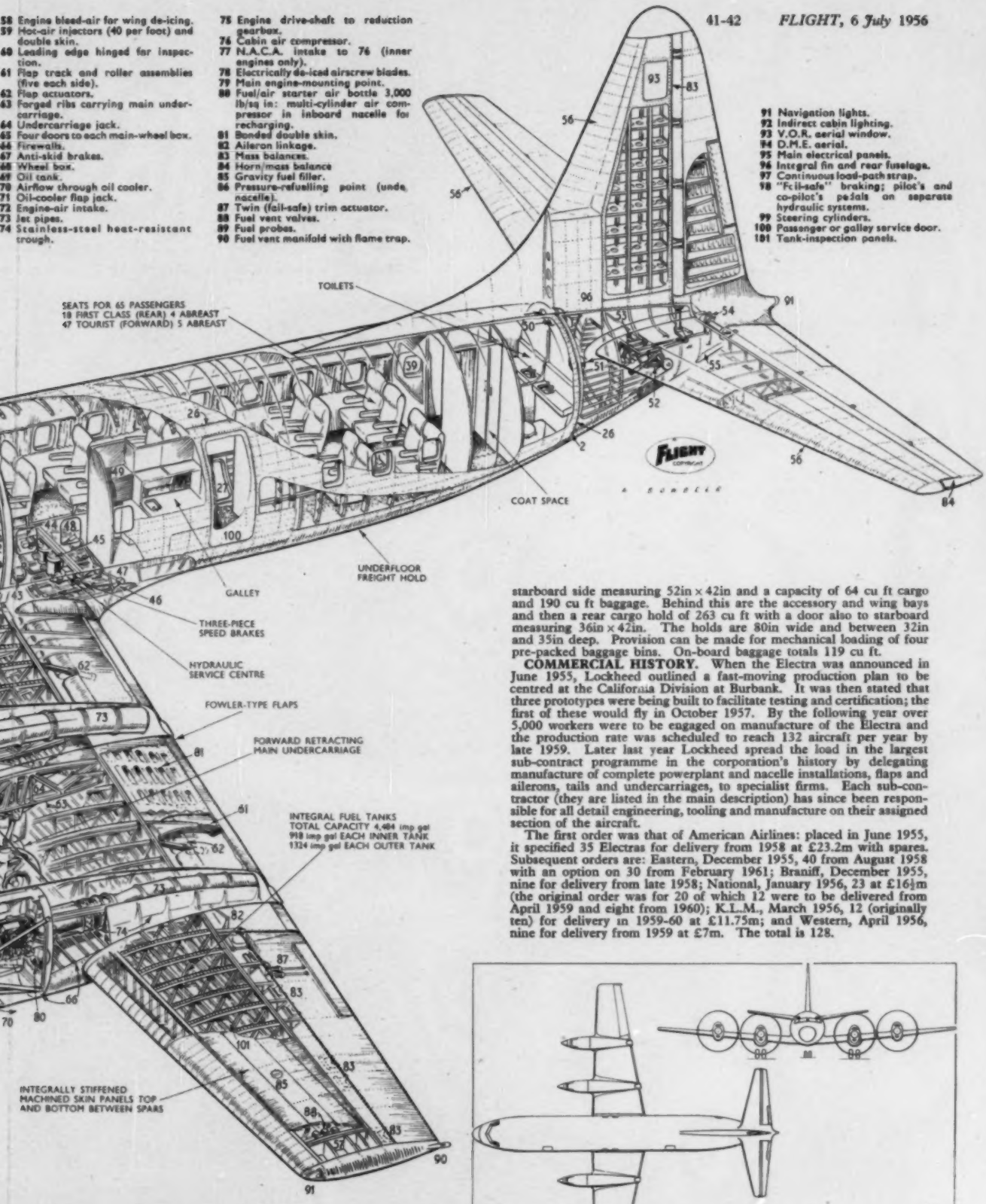
all-five-a
guration.
85 seats,
six lounge

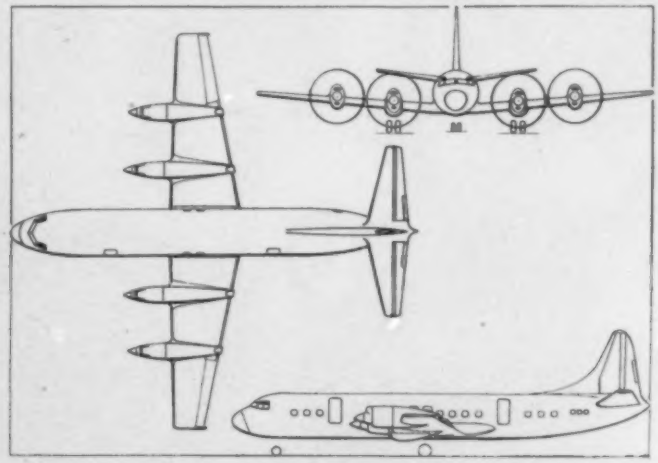
58 Engine bleed-air for wing de-icing.
59 Hot-air injectors (40 per foot) and double skin.
60 Leading edge hinged for inspection.
61 Flap track and roller assemblies (five each side).
62 Flap actuators.
63 Forged ribs carrying main undercarriage.
64 Undercarriage jack.
65 Four doors to each main-wheel box.
66 Firewalls.
67 Anti-skid brakes.
68 Wheel box.
69 Oil tank.
70 Airflow through oil cooler.
71 Oil-cooler flap jack.
72 Engine-air intake.
73 Jet pipes.
74 Stainless-steel heat-resistant trough.
75 Engine drive-shaft to reduction gearbox.
76 Cabin air compressor.
77 N.A.C.A. intake to 76 (inner engines only).
78 Electrically de-iced airscrew blades.
79 Main engine-mounting point.
80 Fuel/air starter air bottle 3,000 lb/sq in: multi-cylinder air compressor in inboard nacelle for recharging.
81 Bonded double skin.
82 Aileron linkage.
83 Mass balances.
84 Horn mass balance
85 Gravity fuel filler.
86 Pressure-refuelling point (under nacelle).
87 Twin (fail-safe) trim actuator.
88 Fuel vent valves.
89 Fuel probes.
90 Fuel vent manifold with flame trap.
91 Navigation lights.
92 Indirect cabin lighting.
93 V.O.R. aerial window.
94 D.M.E. aerial.
95 Main electrical panels.
96 Integral fin and rear fuselage.
97 Continuous load-path strap.
98 "Fail-safe" braking; pilot's and co-pilot's pedals on separate hydraulic systems.
99 Steering cylinders.
100 Passenger or galley service door.
101 Tank-inspection panels.



starboard side measuring 52in × 42in and a capacity of 64 cu ft cargo and 190 cu ft baggage. Behind this are the accessory and wing bays and then a rear cargo hold of 263 cu ft with a door also to starboard measuring 36in × 42in. The holds are 80in wide and between 32in and 35in deep. Provision can be made for mechanical loading of four pre-packed baggage bins. On-board baggage totals 119 cu ft.

COMMERCIAL HISTORY. When the Electra was announced in June 1955, Lockheed outlined a fast-moving production plan to be centred at the California Division at Burbank. It was then stated that three prototypes were being built to facilitate testing and certification; the first of these would fly in October 1957. By the following year over 5,000 workers were to be engaged on manufacture of the Electra and the production rate was scheduled to reach 132 aircraft per year by late 1959. Later last year Lockheed spread the load in the largest sub-contract programme in the corporation's history by delegating manufacture of complete powerplant and nacelle installations, flaps and ailerons, tails and undercarriages, to specialist firms. Each sub-contractor (they are listed in the main description) has since been responsible for all detail engineering, tooling and manufacture on their assigned section of the aircraft.

The first order was that of American Airlines: placed in June 1955, it specified 35 Electras for delivery from 1958 at £23.2m with spares. Subsequent orders are: Eastern, December 1955, 40 from August 1958 with an option on 30 from February 1961; Braniff, December 1955, nine for delivery from late 1958; National, January 1956, 23 at £16½m (the original order was for 20 of which 12 were to be delivered from April 1959 and eight from 1960); K.L.M., March 1956, 12 (originally ten) for delivery in 1959-60 at £11.75m; and Western, April 1956, nine for delivery from 1959 at £7m. The total is 128.



Electra seating-plan the left is a typical five-abreast confi-ation. It provides for seats, or for 91 if the lounge seats are sold.

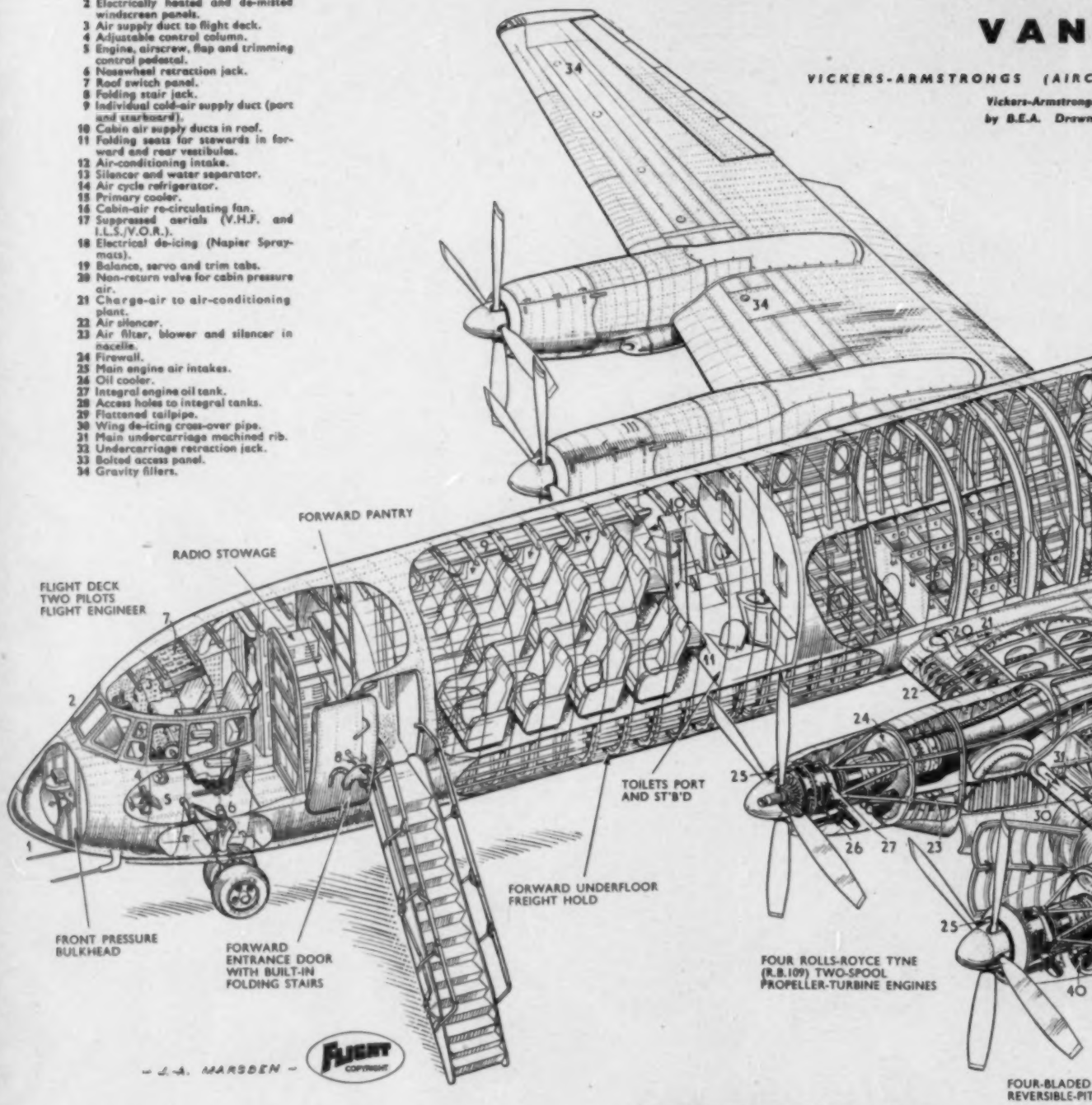
Airliners

VAN

VICKERS-ARMSTRONGS (AIRC

Vickers-Armstrong
by B.E.A. Drawn

1 Fibreglass radome over cloud/collision-warning radar.
2 Electrically heated and de-misted windscreen panels.
3 Air supply duct to flight deck.
4 Adjustable control column.
5 Engine, airscrew, flap and trimming control pedestal.
6 Nosewheel retraction jack.
7 Roof switch panel.
8 Folding stair jack.
9 Individual cold-air supply duct (port and starboard).
10 Cabin air supply ducts in roof.
11 Folding seats for stewards in forward and rear vestibules.
12 Air-conditioning intake.
13 Silencer and water separator.
14 Air cycle refrigerator.
15 Primary cooler.
16 Cabin-air re-circulating fan.
17 Suppressed aerials (V.H.F. and I.L.S./V.O.R.).
18 Electrical de-icing (Napier Spraymats).
19 Balance, servo and trim tabs.
20 Non-return valve for cabin pressure air.
21 Charge-air to air-conditioning plant.
22 Air silencer.
23 Air filter, blower and silencer in nacelle.
24 Firewall.
25 Main engine air intakes.
26 Oil cooler.
27 Integral engine oil tank.
28 Access holes to integral tanks.
29 Flattened tailpipe.
30 Wing de-icing cross-over pipe.
31 Main undercarriage machined rib.
32 Undercarriage retraction jack.
33 Bolted access panel.
34 Gravity fillers.



– J. A. MARSDEN –

FLIGHT COPYRIGHT

35 Double-track flap guide ribs.
36 Single-track flap guide ribs.
37 Flap torque tube.
38 Integrally stiffened wing torque box.
39 Petal-type cowlings.
40 Accessory gearbox.
41 Air intake to de-icing heat exchanger.
42 Heat exchanger (outboard nacelles).
43 Ventral exhaust gas outlet.
44 De-icing hot air duct.
45 Intercommunicating holes in centre web.
46 Spring tab.
47 Aileron leading-edge beak.
48 Detachable wing-tip.
49 Landing lamp.
50 De-icing hot-air outlet.

VICKERS-ARMSTRONGS V.951 VANGUARD

Four Rolls-Royce Tyne (506) turboprops of 4,470 e.h.p.

Dimensions: Span, 118ft; length, 122ft 4in; overall height, 34ft 11in; track, 30ft; wing area, 1,527 sq ft (gross), 1,347 sq ft (nett); root chord, 205in; flaps, 161 sq ft per side; ailerons, 61 sq ft each, aft of hinge; tailplane, 236 sq ft; elevators, 146 sq ft; fin, 132 sq ft; rudder, 88 sq ft; maximum fuselage cross section, 11ft 6in wide and 13ft 7.15in deep.

Weights: Empty weight (B.E.A.), 70,685 lb (structure, 37,670 lb; power plant total, 13,900 lb; furnishings, 9,620 lb; remainder being services and equipment); removable equipment, 815 lb; equipped weight, 71,500 lb; disposable load, 63,500 lb (crew and baggage, 1,410 lb; oil, 158 lb; residual fuel, 250 lb; disposable galley, 1,350 lb; fuel, 39,332 lb; design max. payload, 21,000 lb); maximum weight, 135,000 lb.

Performance (estimated): Take-off field length at 120,000 lb, 4,700ft; climb at 110,000 lb at S.L., i.s.a. at 12,500 l.p. r.p.m., at 170 kt e.a.s., 2,700ft/min (1,600 ft/min at 100,000 lb at 20,000ft); cruise at 13,500 r.p.m. at 110,000 lb at $1.2V_{MD}$ at 29,500ft, 349kt (402 m.p.h.) t.a.s. at 0.063 n.a.m./lb; at 90,000 lb at 28,000ft, 372 kt (430 m.p.h.) at 0.086 n.a.m./lb; V_C = Mach 0.64; V_D = Mach 0.74; landing field length at 95,000 lb at S.L., i.s.a., 4,900ft (3,400ft distance from 50ft).

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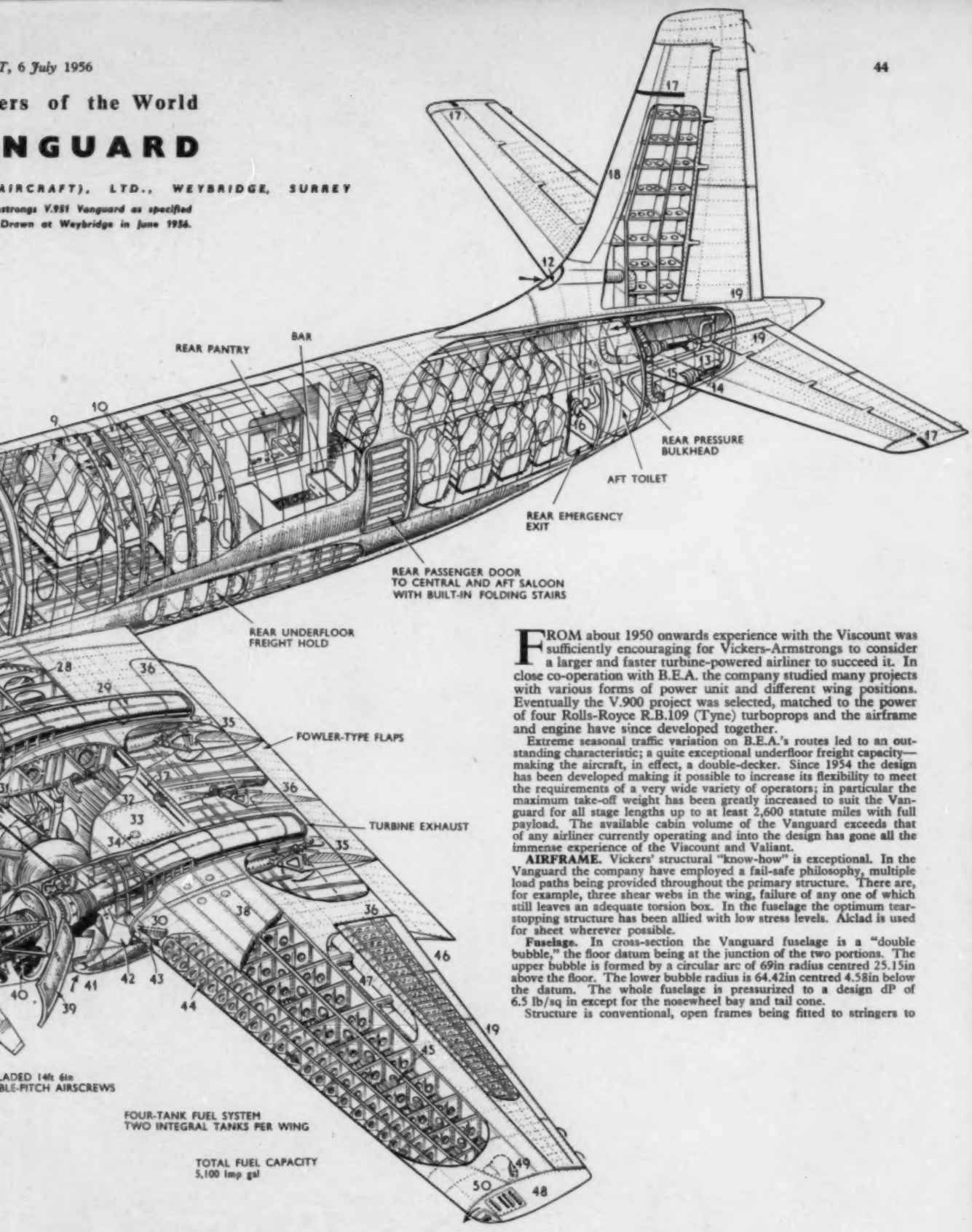
NGUARD

AIRCRAFT), LTD., WEYBRIDGE, SURREY

strongs V.951 Vanguard as specified
Drawn at Weybridge in June 1956.



FROM about 1950 onwards experience with the Viscount was sufficiently encouraging for Vickers-Armstrongs to consider a larger and faster turbine-powered airliner to succeed it. In close co-operation with B.E.A. the company studied many projects with various forms of power unit and different wing positions. Eventually the V.900 project was selected, matched to the power of four Rolls-Royce R.B.109 (Tyne) turboprops and the airframe and engine have since developed together.

Extreme seasonal traffic variation on B.E.A.'s routes led to an outstanding characteristic; a quite exceptional underfloor freight capacity—making the aircraft, in effect, a double-decker. Since 1954 the design has been developed making it possible to increase its flexibility to meet the requirements of a very wide variety of operators; in particular the maximum take-off weight has been greatly increased to suit the Vanguard for all stage lengths up to at least 2,600 statute miles with full payload. The available cabin volume of the Vanguard exceeds that of any airliner currently operating and into the design has gone all the immense experience of the Viscount and Valiant.

AIRFRAME. Vickers' structural "know-how" is exceptional. In the Vanguard the company have employed a fail-safe philosophy, multiple load paths being provided throughout the primary structure. There are, for example, three shear webs in the wing, failure of any one of which still leaves an adequate torsion box. In the fuselage the optimum tear-stopping structure has been allied with low stress levels. Alclad is used for sheet wherever possible.

Fuselage. In cross-section the Vanguard fuselage is a "double bubble," the floor datum being at the junction of the two portions. The upper bubble is formed by a circular arc of 69in radius centred 25.15in above the floor. The lower bubble radius is 64.42in centred 4.58in below the datum. The whole fuselage is pressurized to a design dP of 6.5 lb/sq in except for the nosewheel bay and tail cone.

Structure is conventional, open frames being fitted to stringers to

s of the World

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RCRAFT), LTD., WEYBRIDGE, SURREY

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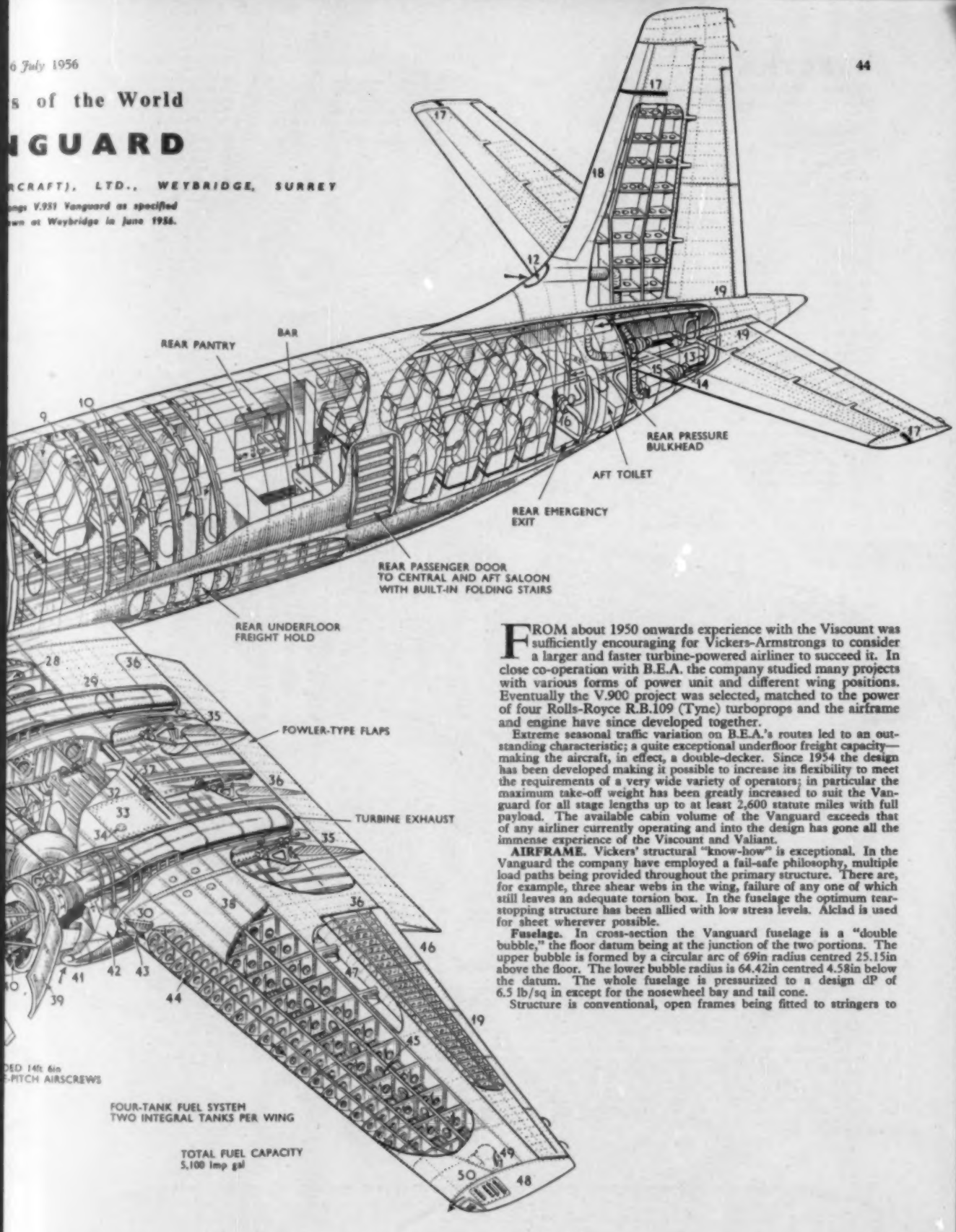

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which the skin is flush-riveted in large panels. The frames immediately adjacent to door cut-outs are attached directly to the skin to provide duplicate load paths; the areas between the windows are protected by tear-stopping, closely-pitched vertical stiffeners attached directly to the skin. Aerodynamic calculation and tests show that a tail skid or bumper will not be required but at least for preliminary flight testing a steel rubbing plate will be fitted at the area of contact in the event of an abnormal tail-down or flapless landing.

The upper floor is composed of removable light-alloy panels stiffened by longitudinal channel sections and designed as a passenger floor only. Rail fixings are employed for seats, bulkheads and other items of furnishing, such as buffets and wardrobes. The level freight floor is stressed to a local intensity of 200 lb/sq in and a general loading of 150 lb/sq ft.

Basically the windows are identical with those of the Viscount, in that they are ellipses 26in × 19in; 25 are standard windows in the parallel fuselage section, eight are arranged as emergency exits and five are handed left and right owing to the contour of the rear fuselage. There are in addition seven portholes for toilet and pantry regions. In the flight deck a forged frame carries eleven large windscreen panels. The main entrance door, forward to port, measures 73in × 39in and incorporates hydraulically operated folding steps; the latter are separate from the door which is at present arranged to hinge outwards on parallel links to lie 6in from the fuselage skin when open. Opposite is an emergency exit and service door 66in × 26in. At the rear of the cabin is a second passenger entrance door and steps identical with the first with a similar 66in × 26in door opposite. A third emergency exit, 50in × 24in, is provided further aft on the port side. Each freight hold is served by doors 66in wide × 51in on the starboard side, each split longitudinally into halves hinged upwards and downwards. All doors open outwards and are sealed pneumatically, a valve preventing opening with a dP greater than 0.4 lb/sq in.

Wing. After extensive investigation, the optimum section was found to be that of the Viscount, slightly thinned down to 15 per cent at the root and 13 per cent at the tip. The chief evidence of fail-safe design is the employment of three shear webs, any pair of which can maintain an adequate torsion box. This structure marks no lack of belief in the single-spar principle of the Viscount, but is merely better suited to the Vanguard. One reason is that integral tankage is essential for the best range and such construction is impracticable with a single spar.

There are five main sections: the centre section projecting just beyond the fuselage skin, two inner planes extending immediately beyond the outboard engines and two outer wings. The outers are not normally removed for overhaul but could be replaced for repair. The basis of the wing is a torsion box formed by the three shear webs and top and bottom machined integrally stiffened panels, together with closely-pitched pressed ribs. In general the panels are 20 to 23.26in wide and have six or seven flanges. They are untapered and fade out at the sides as they meet the leading and trailing spar webs. The two upper centre panels of each wing are bolted to the shear webs, the remainder being riveted.

Except for the centre section, the complete torsion box with its end ribs is sealed to form integral tankage. Access to the interior is gained through four bolted hatches on the upper surface of the inner planes and in the outer wings *via* access panels in the forward or rear webs after removing the detachable leading edge or aileron. The tips are detachable metal pressings. Anchoring points for the powerplants and undercarriage are all external to the torsion box, on massive machined ribs. The machined panels in the torsion box are painted to prevent corrosion.

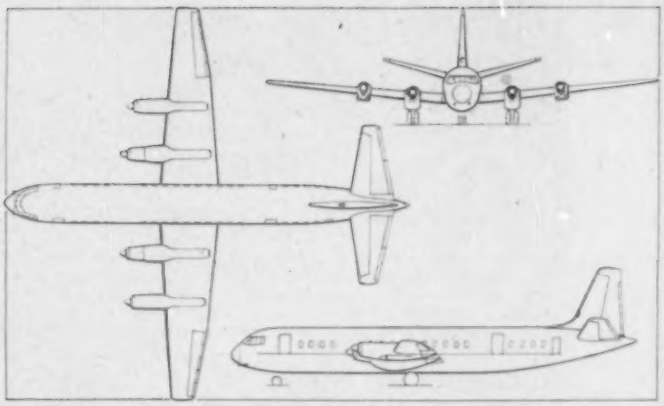
Tail. Here the structure is conventional. The fin is divided into a lower portion attached to the same frames as is the tailplane, and an upper section joined to the lower by removable pins. The leading edge, incorporating de-icing elements, is detachable. The rudder is made as a single surface with horn balance and spring and balance tabs along almost the entire trailing edge. Each half of the fixed-incidence tailplane has 15 deg dihedral and is anchored to a centre section integral with the rear fuselage. Three shear webs carry multiple ribs and the leading edge, with electro-thermal de-icing elements, can be unbolted from its location on the front shear web. The elevators have horn balance, set-back hinges and trim, balance and spring tabs along almost the whole trailing edge. Thickness/chord ratio of the horizontal tail is 14 per cent at the root and 12 at the tip, and the junction with the rear fuselage has been carefully developed to prevent break-away at high Mach numbers.

Undercarriage. This is of Vickers design and manufacture. The nose undercarriage has twin wheels steered by twin hydraulic cylinders through ±70 deg, sufficient to pivot the aircraft about either main leg (with 360 deg movement when disconnected); the unit retracts forwards hydraulically into an unpressurized bay with twin doors.

Each main leg—identical port and starboard—is hinged to forgings carried beneath the main wing box. Each unit has twin wheels with large 53in tyres inflated to the low pressure (by modern standards) of 98 lb/sq in, and retracts hydraulically forwards into the inner nacelles which are closed by double doors. Wheel and brake equipment is specified by Dunlop or Goodyear, the brakes being of the multi-piston disc type with anti-skid control. All undercarriage units can be mechanically unlocked to free-fall (assisted by a sprung toggle strut) in emergency; wheels-down limit is 200 kt e.a.s., since use as an air brake appears unnecessary.

Flying Controls. All flying controls are manually operated by push-pull rods and spring tabs. Relatively speaking the tabs do more than on the Viscount and they occupy virtually the whole trailing edge of each surface. Elevator balance is 25 per cent set-back hinges and horns (as on the Viscount 810). The rudder also has horn balance and a rounded nose with a small gap. Apart from the use of spring tabs the ailerons resemble those of the Viscount, with a leading-edge beak and fabric seal. The dual cockpit control columns are pivoted at floor level. Mechanical locks are designed to meet tail gusts of 80 kt and are tied to the engine throttles by the conventional nuisance-bar technique.

Fowler-type flaps are employed, with a maximum angle of 40 deg.



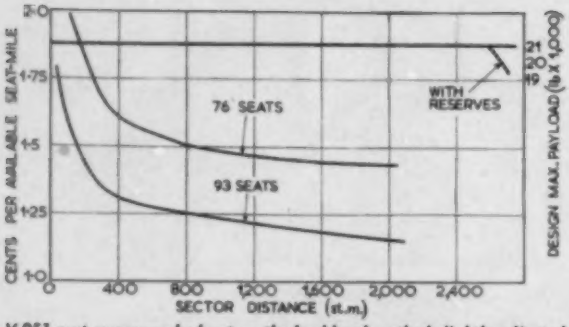
Double-slotted flaps would, for the same lift, have needed to run out to a greater angle and the increased drag would have adversely affected approach and baulked-landing climb performance. There are four sections on each wing, the chord being constant throughout. All the flap portions are actuated by a hydraulic jack, in the inner wing, through a continuous torque tube and a conventional cable system. Emergency operation is effected by an electrically driven pump feeding the same jack through a separate pipe system. Each flap section runs out along internal steel tracks (at one stage in the design these tracks projected externally), adjacent sections being linked by bogies running in the tracks on rollers.

POWERPLANT. The engine is the Rolls-Royce Tyne 500-series turboprop. Each engine drives a 14ft 6in four-blade airscrew (de Havilland or Rotol are specified), fitted for auto-feathering (or pitch-coarsening), feathering and reversing, with electric de-icing and advanced safety features.

The Tyne has two axial compressor spools, the design pressure ratio being 13:1. The high-pressure assembly is self-contained but the three-stage low-pressure turbine drives both the front compressor spool and the double-reduction, quiet-running gearbox (0.064:1) to the airscrew. The first Vanguards will have the "stage I" Tyne rated at 4,020 s.h.p. (4,470 e.h.p.) dry. Stage II engines will be available in 1961, with improved turbine-disc cooling and blade materials to permit the top temperature to be raised to a value giving 4,600 s.h.p. (5,075 e.h.p.) wet; it will be possible to convert engines to this standard retroactively. By early 1963 the stage III Tyne should be in service, rated at 5,500 e.h.p. by improving the cooling of the h-p. turbine blades.

All engines are interchangeable, complete with airscrews. Each unit is mounted on a triangulated structure off the firewall and can be changed (leaving the cowling and accessory gearbox undisturbed) in approximately 30 min. If required, water/methanol injection is available. The exhaust gas leaves through a tailpipe—partly single and part-bifurcated—which passes across the wing to a propelling nozzle above the trailing edge. The cross-section of the nacelle and pipe fairing is reduced above the wing to minimize local airflow acceleration at high Mach numbers.

A Rotol accessory gearbox is mounted in the lower part of each nacelle with a mechanical drive from the l-p. spool. Each box drives an airscrew parking brake and a 50 kVA de-icing alternator; the inner boxes also drive cabin blowers and hydraulic pumps. Engine starting is electric by a D.C. starter/generator which also serves as the main source of electric power. The starter drives the h-p. spool only, the



V.951 cost curves worked out on the Lockheed method slightly adjusted to suit the aircraft. Assumptions: 15 per cent American import duty included. Payload/range reserves are 5 per cent contingency, 200 n.m. diversion (cruise alt.) and 1 hr hold at 5,000ft; without reserves full payload can be carried 3,120 miles, allowing 1,000 lb plus 5 per cent.

Airliners of the World

VANGUARD

starting load therefore being relatively low, so that standard Dart-type ground trucks can be used. The lubrication system, using synthetic oil, is self-contained within each engine. An annular tank surrounds the intake casing and has a capacity of 44 pints, 16 of which are available for feathering. Twin air-cooled oil coolers are mounted beneath each tank and fed from a separate ram intake. A fireproof bulkhead lies between the compressor and combustion sections and shrouding is provided around the combustion chamber, jet-pipe and accessory bay. Graviner Firewire strip detection is specified and methyl-bromide bottles are mounted in each nacelle, it being possible to discharge a second shot from the contents of the nacelle adjacent to that affected.

Single-lever control is envisaged. Owing to the two-spool layout of the engine, it is necessary to employ a fully-reversing airscrew. The two compressor spools are joined by a bleed valve automatically controlled by corrected speed signals from the two shafts, so that the airscrew r.p.m. can be maintained at 75 per cent of the take-off value (i.e., 11,500 l-p. shaft) on the approach with minimum fuel flow to give high drag. Special precautions are required to ensure that maximum engine r.p.m. are restricted to safe levels by matching the minimum airscrew pitch to the appropriate air speed.

Synchronization is on an r.p.m. basis, although phase-synchronization is under investigation. For reverse thrust, a single selector arms the reversing circuits and allows the power levers to move to the reverse-idling position once manual catches on the throttles have been raised. The airscrew brake circuit is fed *via* inter-locks in the high-pressure fuel cock control circuit, which also allows the hydraulic folding-stairway circuits to be energized. With an engine feathered, the h-p. spool is free to spin, but provision may be made for a brake.

SYSTEMS. Air-conditioning. Design dP is 6.5 lb/sq in. Each inboard accessory gearbox drives a Godfrey blower of the S.R.M. type; normal supply from both is 150 lb/min, equivalent to a complete change of cabin air about 20 times per hour. Full pressure can be maintained with either blower alone. A cold-air unit (air-cycle turbine) is mounted behind the rear pressure bulkhead (where it cannot be heard in the cabin) and fed through intercoolers from a ram intake in the fin. For operation in extreme climatic conditions, combustion heaters, or a closed-cycle Freon refrigerating system can be incorporated. Without the latter, ground-conditioning can still be achieved by running an inboard engine (both of which are used for taxying).

Air is introduced along the whole length of the cabin through the ceiling and extracted through louvres in the wall skirting. Temperature in the flight deck is selected by mixing air fed from separate hot and cold ducts, with independent control.

Fuel. All fuel is housed in four integral tanks formed by the wing box. Each inner tank has a capacity of some 1,850 gal and each outer about 700 gal, giving a total capacity of 5,100 gal, of which all but about 200 lb is usable. There is no fuel in the centre section. The complete system can be pressure-fuelled in ten minutes, or de-fuelled in 40 minutes, through a single socket beneath the starboard wing root. Maximum flow is 600 gal/min at 50 lb/sq in, and an adaptor can be fitted to allow for dual hoses. Gravity fillers are provided above the outer end of each tank. Supply to the engine is conventional, with continuous fuel heating if necessary to prevent icing. Fuel jettison can be provided for, using the tank booster pumps, and mass-flow fuel-measuring equipment is standard.

Hydraulics. Each inboard accessory gearbox carries a Lockheed pump which pressurizes the system to 3,000 lb/sq in. Air pressure in the reservoir maintains a positive feed to the pumps. Hydraulic services include the flaps, undercarriage, wheel brakes and steering; failure of either pump doubles operating times. Mineral-based fluid (D.T.D. 585) is specified but the use of fire-resistant fluids has been allowed for and, with suitable seals, Skydrol 500 can be used. Electric cables and sealing materials are suitable for use of Skydrol. There are no h-p. pipes in the pressure cabin.

Electrics. After carefully considering the merits of paralleled A.C. systems, it was decided that the Vanguard should generate all its main power as D.C. at 28V. Each generator also acts as an engine starter, and is bolted direct to the Tyne wheelcase and geared to the h-p. compressor. Of English Electric design, the starter/generator units are continuously rated at 12kW and are connected in parallel to feed a new design of busbar embodying special features to prevent earth faults. Storage batteries are carried under the floor, and with all normal services in use no discharge occurs at taxying r.p.m. of 8,000.

Two inverters provide 400 c.p.s. three-phase 200-V supplies for instruments, autopilot and electronics. In addition, each accessory gearbox drives a 50 kVA self-exciting alternator feeding nominally similar current for de-icing purposes. These alternators are frequency-wild and are not paralleled; their output is supplied to the Freon system, if the latter is fitted.

Ice Protection. The entire span of the wing leading edge is thermally de-iced in a manner generally similar to that of the Viscount. Each outboard nacelle houses a cross-flow heat exchanger in which exhaust gas tapped from the tailpipe heats fresh air from a ram intake on each side of the nacelle. The gas is dumped overboard and the heated air ducted through the double-skin leading edge and expelled from flush exits at the tips. The heat exchangers are of a new Gallay design and can be slid out through the underside of each nacelle. Temperature control is automatic, the system being designed to meet icing conditions at −30 deg C at 25,000ft.

Leading edges of the fin, tailplane and horn balances are heated by Napier Spraymat electric elements. Each leading edge can be removed as a unit. Electric cyclic de-icing is likewise applied to the airscrews and to the Tyne intakes, the total load being 26 kW. All these loads are supplied from the *ad hoc* alternators. Triplex Gold Film or Nesa glass is used for all the transparent panels in the flight deck, with stand-by fluid sprays for the pilots' panels. The electric de-icing equipment is rated for flight up to 30,000ft. Continuous fuel heating is specified and the engine intake guide vanes are anti-iced by compressor bleed air.

FLIGHT EQUIPMENT. Accommodation is provided for a flight crew of three: captain, first officer and a third member—probably a supernumerary or check-pilot—seated behind the pedestal. Behind, on the port side, is a fourth seat with stowage for books and maps close at hand. The aircraft can be flown by one pilot and one other crew-member.

On B.E.A. Vanguard 951 aircraft specified equipment includes the Smiths Flight System and the S.E.P.2 autopilot. Provision is made for the following aerials: weather radar (nose radome); A.D.F. (suppressed above the fuselage, external sense aerials below); V.H.F. (fin-slot); I.L.S./V.O.R. (slots in each tailplane); glide path (suppressed within nose radome); Decca (suppressed beneath fuselage); transponder (omni-directional beneath fuselage); H.F. communications (duplicated suppressed and hand-rail type); marker (suppressed beneath fuselage); Tacan (provision only); and suppressed ventral aerials for a radar altimeter. Radio racking is provided on the flight deck, a ducted fan extracting heated air.

PAYLOAD ACCOMMODATION. A variety of interior layouts is possible. The standard V.951 with B.E.A. is likely to be as shown in the main drawing, but arrangements provide for up to 115 (all five-abreast) or about 76 in a first-class version. The cabin can also accommodate six-abreast seating and the present mock-up has a section fitted with double rows of the Air France Viscount type triple seat. Nominal provision is made for "carry-on" luggage forward of the rear entrance door. All pantries, bars and bulkheads are readily removable, although toilets are mounted in the plane of the airscrews in all passenger versions. The standard 93-seat V.951 is fitted for a cabin crew of five.

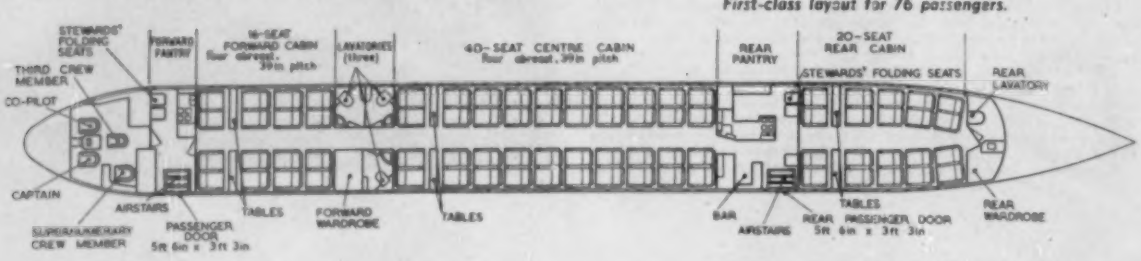
Passenger-service panels (lights, cold air, etc.) can readily be adjusted beneath the overhead racks to suit the seat pitch. The latter is standardized at 39in, corresponding with the spacing of the windows—which, as already described, resemble those of the Viscount and have upper and lower blinds in place of curtains. In general, the floor width is 119in. Approximate lengths of the three saloons (seat area only) in the V.951 are, from the front: 175in, 409in and 214in; the total volume of cabin above the floor is no less than 5,894 cu ft.

Under the floor are the two capacious freight holds. Both have floors 60in wide; the forward hold is 342in long (800 cu ft) and the rear 297in (630 cu ft). Each door sill is 4ft 8in from the ground and either hold can accept a complete Tyne engine. Minimum hold temperature is 35 deg F.

COMMERCIAL HISTORY. Production tooling is at present being prepared and it will be used in the construction of the first aircraft which is scheduled to fly in the autumn of 1958. This aircraft, although not strictly a prototype, will be retained by Vickers for special tests and demonstrations. As already noted, the entire planning of the design was undertaken in particularly close partnership with British European Airways, and the Corporation placed an order for 20 in October last year at a price, with spares, of approximately £1m each. Originally, these aircraft were to have been of the now-defunct V.901 type, but all Vanguards will now be of the V.950 series with increased range.

First deliveries to B.E.A. are scheduled to commence in March 1960. A number of other operators are at present holding discussions with Vickers-Armstrongs, but no detail of prospective purchasers may be given.

First-class layout for 76 passengers.



Airliners of the World

FRIENDSHIP

ROYAL NETHERLANDS AIRCRAFT FACTORIES FOKKER, AMSTERDAM

WITHIN six months of the Fokker F.27 Friendship's maiden flight in November 1955, six airlines had placed firm orders for the Dutch feederliner, and all told about 50 aircraft were the subject of firm orders or options. Significantly, the Friendship has appealed strongly to local-service airlines in the U.S.A., and it was a great encouragement to its makers—whose home market is small (K.L.M. have ordered two)—when Fairchild recently decided to build the Friendship under licence in the U.S.A.

The reasons for the Friendship's early sales success are not hard to seek. The aircraft is the outcome of thorough market research by the Fokker design team, and its layout and capacity were chosen to appeal to that vast market which, difficult to define in simple terms, is served by the veteran DC-3 and which still remains virtually untapped by a modern replacement aircraft.

But perhaps the Friendship's greatest attraction is that it offers the economy and sophistication of turboprop power to local-service and off-the-beaten-track operators, and its Rolls-Royce Darts, now so thoroughly established everywhere by the Viscount, were clearly the most logical choice of powerplant. Indeed, a trend toward employment of Friendships and Viscounts as partners has begun.

Fokker's market research pointed strongly to the need for a 28-36 passenger aircraft, with a large freight capacity, and having an optimum stage distance of about 300 miles. While the aircraft should include the most-up-to-date refinements, in particular cabin pressurization, it should also be kept simple and rugged and its interior designed to be as versatile as possible. A high-wing layout was chosen for reasons of increased aerodynamic efficiency, faster ground loading, and improved passenger view, and high aspect ratio (12) with high-efficiency compound flaps were adopted to achieve the best possible field performance.

Extensive use has been made by the Fokker company of British accessories, equipment and structural processes, and apart from Rolls-Royce the British industry's contributors include Rotol, Dowty, Aero Research, Dunlop, Standard Telephones, Smiths, Fibreglass, and Rumbold.

Airframe. The fuselage is of stressed skin, semi-monocoque construction consisting basically of two assemblies, front and main. The cross-section of the main pressurized cabin assembly comprises two circular segments of different radii, the cabin floor forming the common chord. The bottom of the main fuselage has been designed to provide extra strength against the possibility of a wheels-up landing. Emergency exits are combined with two of the cabin windows, and a floor-level emergency escape hatch is provided on the starboard side of the cabin opposite the main entrance door. A large cargo door is included on the port forward side of the fuselage. Extensive use is made of Redux bonding in the attachment of stringers to skin.

The wing is of stressed-skin construction, and comprises the centre-section, which carries the engine nacelles, and two detachable outer-wing sections. The centre section and outer-wings each possess three main component parts: a rigid torsion cell; a leading edge section; and a trailing edge section. The torsion cell is formed by front and rear main spars, top and bottom skin panels, ribs, and closely spaced stringers. The spars are of particular interest; the booms are bonded angle laminations, and the change in section is achieved by progressively reducing the number of laminations to combine strength with lightness and simplicity of construction. Similar progressively laminated reinforcing panels are glued to the skin at the six main wing-junctions.

The outer wing is covered by a machine-tapered skin over the two inboard sections, and the integral fuel tanks are located between the front and rear spars. Flaps and ailerons are of conventional construction.

The stressed skin construction of the tailplane and fin is similar to that employed on the wings. Elevators and rudder are conventional.

The main undercarriage is an orthodox Dowty type oleo-pneumatic shock absorber fitted into a telescopic leg with twin Dunlop wheels, pneumatic brakes (Maxaret), and 60 lb/sq in tyres. The nose undercarriage is of Dowty levered-suspension "Liquid-Spring" type, with pneumatic power-steering by Dunlop.

Powerplant. The engines of the production Friendship will be Rolls-Royce Dart 511s of 1,600 s.h.p., driving Rotol 12ft four-blade airscrews. The prototype was initially fitted with Dart 507 engines (1,540 s.h.p.) and 10ft airscrews, but has recently been re-engined to production standard.

The engine nacelles are in three sections: (1) nacelle centre-piece, having a fixed connection with the wing and containing the engine-mounting brackets, main undercarriage, and water/methanol tanks; (2) detachable powerplant complete with airscrew and cowling, and (3) detachable tail portion housing electrical equipment. At the forward end of the centre-piece is a fireproof bulkhead through which passes the outwards-inclined shrouded jet pipe. The Rotol auxiliary gearbox is mounted flat in a separate compartment behind the firewall, with the majority of accessories vertical.

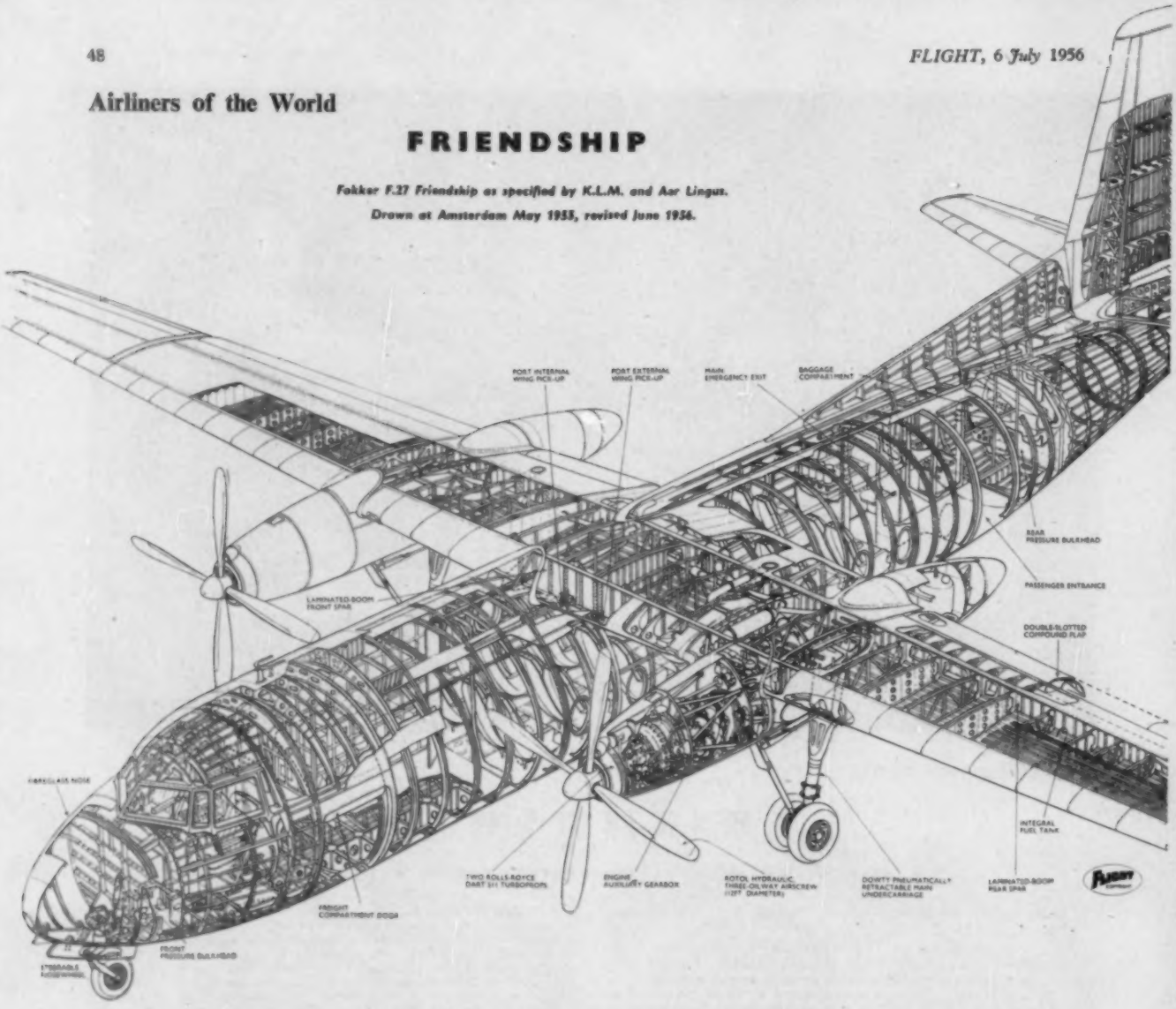
Flight Deck. The flight deck comprises a pilot and co-pilot who have access to all controls and equipment. Provision is made behind the flight deck bulkhead for a third crew member if required. There are two conventional flight panels, one for each pilot, with engine instruments between. The central control pedestal includes throttles, fuel cocks, trimmers, flap levers and undercarriage selection. The overhead panel

Airliners of the World

FRIENDSHIP

Fokker F.27 Friendship as specified by K.L.M. and Aer Lingus.

Drawn at Amsterdam May 1955, revised June 1956.



incorporates radio control, engine starters and relight buttons, and electrical switches.

Layout of the flight deck was developed in close association with K.L.M., and appears to provide uncommon comfort, visibility and headroom.

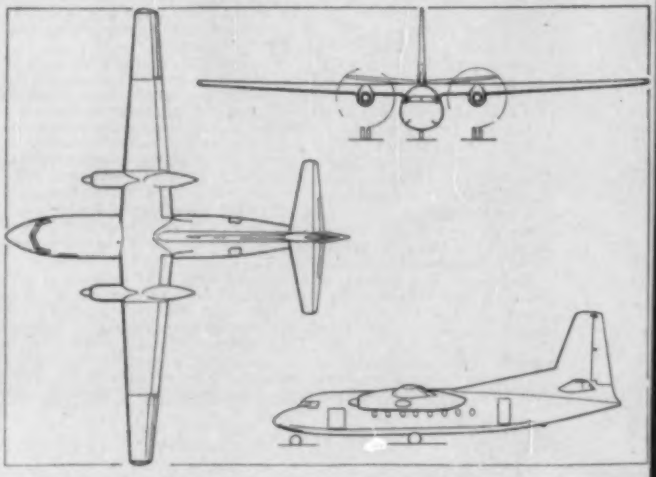
Flying Controls. Duplicated cockpit controls are fitted, and the control surfaces are conventionally operated by cables and push-pull rods, each surface having a servo-trim tab. A gust-lock lever in the cockpit allows only one engine at a time to be run to take-off r.p.m. with the flying controls locked. The flaps extend from fuselage to ailerons, and are of double-slotted compound type designed by Fokker. They extend for almost three-quarters of the total wing span, and are about one-third of the wing chord in depth. Maximum lift coefficient for take-off is 3.7.

Cabin Air System. The Friendship is pressurized to a maximum differential of 4.16 lb/sq in (8,000ft at 20,000ft). Two Godfrey cabin blowers, one driven by each engine, are the source of supply. The pressurized air enters through apertures under the luggage racks and through a separate duct to the cockpit, and is discharged *via* relief valves from an outlet aft of the rear pressure bulkhead. Air conditioning equipment includes a turbine-expansion cold-air unit located behind the rear pressure bulkhead, and automatic temperature control to maintain the cabin at 70 deg F in the lowest outside air temperatures.

Electrical System. The electrical installation comprises two separate systems, (1) a 28 volt D.C. circuit, supplied by one engine-driven generator on each engine charging a 24 volt battery, and, (2) an A.C. system using 115 volt, 400-cycle main and auxiliary inverters run off normal aircraft D.C. supply, and two engine-driven alternators giving 208 volts, 400 cycles.

Pneumatic System. There are no hydraulics in the Friendship; pneumatic power was chosen to operate the undercarriage, brakes, and nosewheel steering. The system is powered by two Dunlop compressors, one driven by each engine, at 3,000 lb/sq in storage pressure. All actuators operate at 1,000 lb/sq in. The system is designed so that each half is independent in the event of failure.

The undercarriage air supply is controlled by an electro-pneumatic valve which has a mechanical over-ride to guard against electrical failure; retraction time is 5 sec. Nose-wheel steering is controlled by an infinitely variable valve coupled by lever and cable to the steering wheel on the left of the instrument panel (duplication for the first officer is optional). Power supply is cut off at a steering angle of 58 deg, and the self-centring device in the steering motor ensures that the whole assembly is centralized for retraction. The wheel-brakes are powered by the main storage system, with a small supplementary



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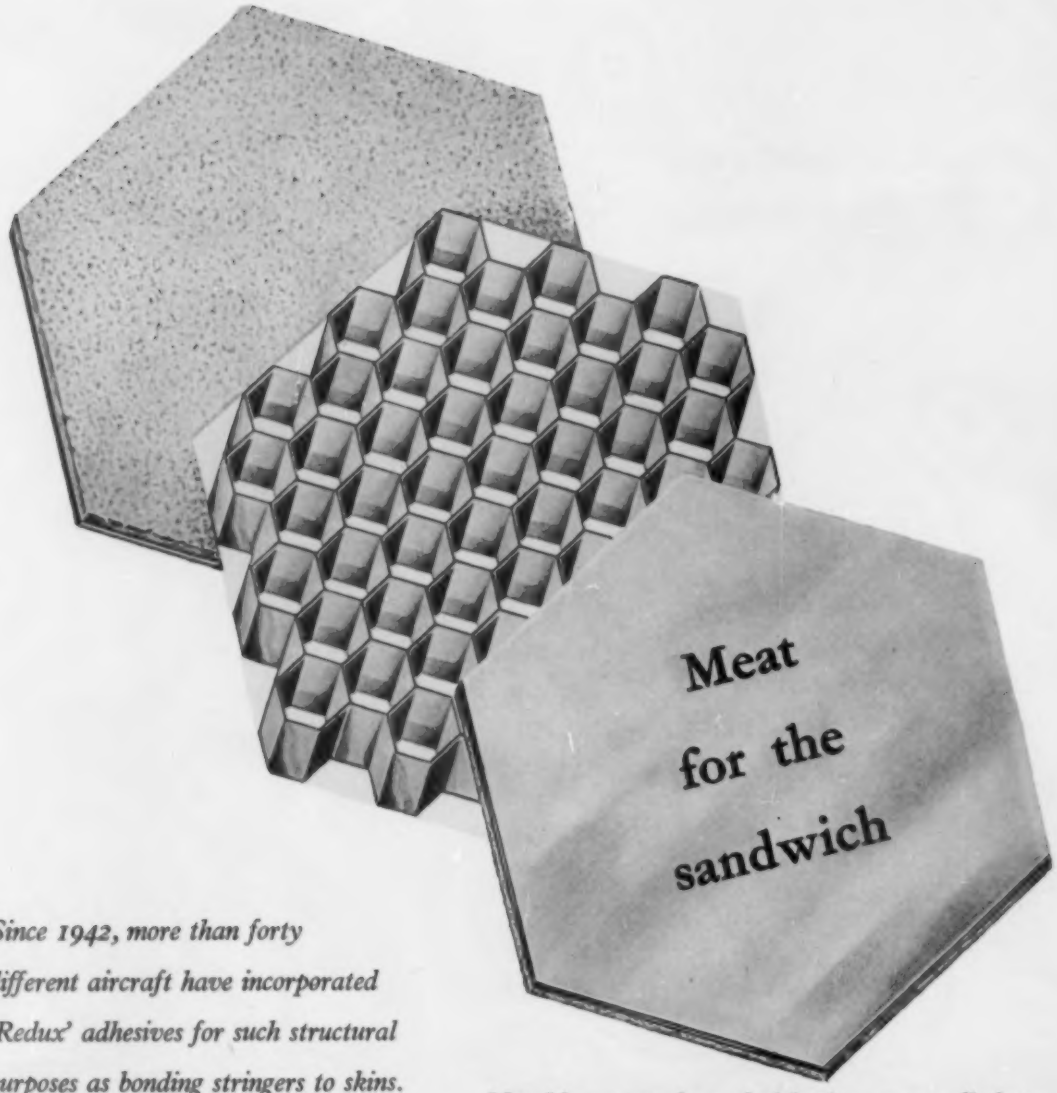

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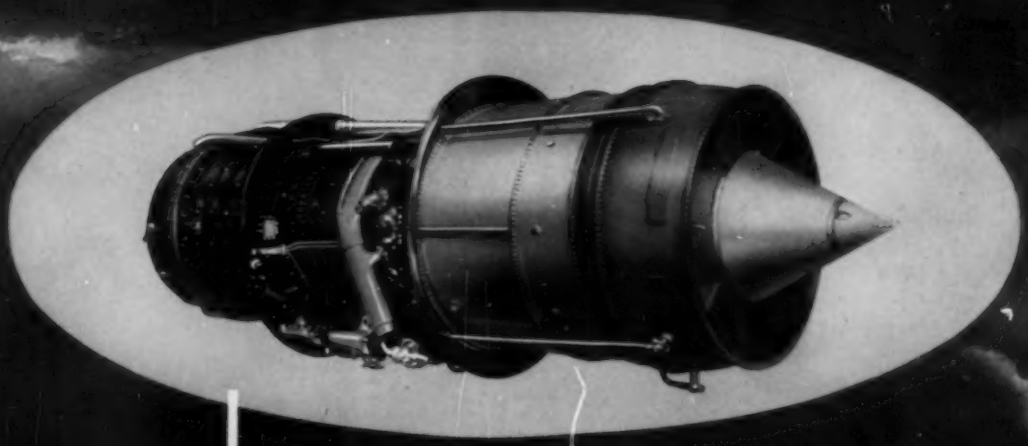

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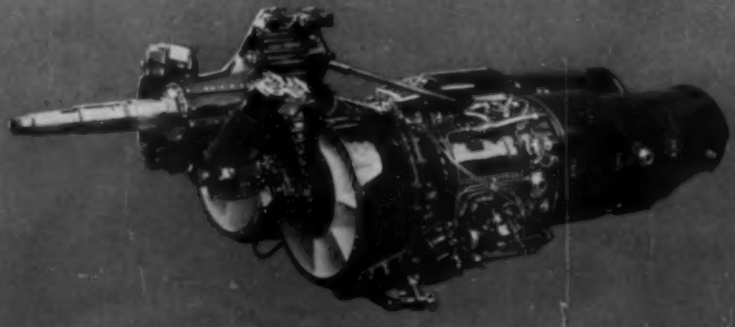

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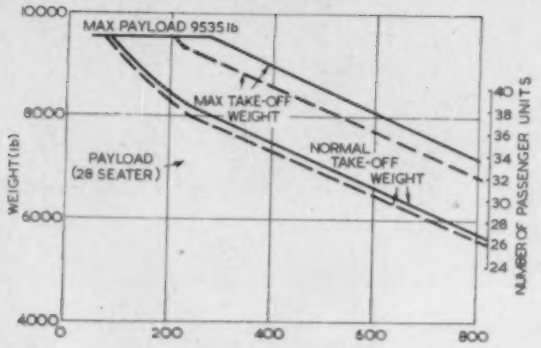
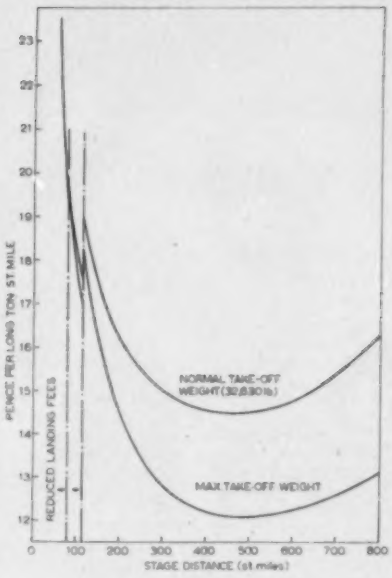




In the payload/range graph the broken lines allow for I.F.R. The cost curves are based on S.B.A.C. issue 2 assuming 3,000 hr per annum; the kink is due to reduced landing fees on short stages.

FRIENDSHIP

air bottle to maintain full pressure should the main air bottle pressure be low. The brakes are double-plate assemblies, and pneumatic Maxaret anti-skid units are fitted. Parking is achieved by depressing the toe-pedals and pulling a lock lever.

An emergency pneumatic system provides power for lowering the undercarriage and applying the brakes should there be a failure in the duplicated main supply system.

Fuel System. Total fuel capacity is 818 gallons contained in integral wing-tanks. Port and starboard fuel systems are connected by a cross-feed line, and a small collector tank in each nacelle has a low-pressure fuel pump to reduce the amount of residual fuel. Refuelling is via either under-wing pressure connections or through over-wing filler caps.

Ice Protection. The wings and engines are protected from ice formation thermally, by exhaust-heated fresh air supplied to the leading edges. Tailplane de-icing is effected by electric heating elements. Operators have the alternative choice of pneumatic overshoes for de-icing.

Radio. A typical radio installation, variable according to customers' requirements, comprises: Bendix or Collins V.H.F.; Collins glide-path and marker beacon receiver; Bendix A.D.F.; Standard Telephones V.H.F.; Collins H.F.; and Bendix intercom. Provision is made for the duplication of equipment, and for the fitting of a flight director system if specified.

Payload Accommodation. Originally the standard version of the Friendship accommodated 28 passengers in four-abreast seating (fuselage diameter is 8ft 10in), plus 280 cu ft of cargo space in the forward part of the fuselage. Late last year, when the promise of increased power became a reality, it was decided to stretch the fuselage 3ft forward of the wing, and to use the additional cabin space by installing an extra row of four seats. Cargo capacity remained the same, being accessible through a 4ft by 3ft 7in door on the port side (sliding inwards and upwards on rails), but passenger accommodation was thus increased from 28 to 32.

This became the standard version. At the aft end of the cabin, opposite the entry door on the port side (5ft 5in by 2ft 5in, sliding inwards and aft) is a pantry with a seat for a stewardess, and a lavatory-washroom; at the extreme aft end, up against the pressure bulkhead, is a luggage compartment of 100 cu ft. In addition there is a wardrobe on the port side just forward of the entry door.

Obviously the layout lends itself well to variations. By moving the bulkhead which separates the cabin from the forward cargo compartment, the latter can be reduced in capacity by about 100 cu ft to accommodate an extra row of seats, bringing the total number of passengers up to 36. Aft end facilities remain unchanged. Again, by dispensing with the aft wardrobe and moving the galley forward to the port side of the cargo compartment, a further row of seats can be installed at the rear of the cabin, bringing seating capacity up to 40; and no doubt, by dispensing with forward cargo space altogether, and adding further passenger windows and removing the freight door, seating capacity could be increased to at least 44, a possibility which Fairchild is no doubt considering for the American local-service airlines.

Commercial History. The Friendship is Fokker's first airliner for 20 years, and can trace its ancestry to the famous Fokker airliners of the 'thirties such as the Trimotor F-7, F-10, F-12 and F-18 which were the standard equipment of many airlines, K.L.M. in particular. Fokker undertook the market research which resulted in the Friendship in 1951 and 1952. The decision to go ahead with the construction of a prototype was taken in the summer of 1952, and the first flight took place on November 24, 1955. By then the first order had been placed (two for K.L.M.), and last April the licence agreement with Fairchild—which had been the subject of negotiation for some time—was finally concluded. Last February, too, the Breguet company of France signed an agreement with Fokker whereby the joint production of Friendships, possibly with other French firms such as S.N.C.A.S.O., was envisaged.

The present Friendship order book—which significantly already includes three airlines which have ordered Viscounts—is as follows: K.L.M., two; West Coast Airlines, four plus option on four (Fairchild-built); Mackey Airlines, two plus an option on two (Fairchild-built); Aer Lingus, four; Frontier Airlines, two plus an option on four (Fairchild-built); Trans-Australia Air Lines, six; Netherlands Government, one. Total of firm orders: 21. Other operators reported to have placed options are South West Airlines (Fairchild-built); Bonanza (four, Fairchild-built); Mohawk (Fairchild-built); and B.K.S. Air Transport (four).

Present plans are that Fokker should build a run of 50 and Fairchild 100. First deliveries are due next year and the price quoted for an Amsterdam-built machine is about £165,000.

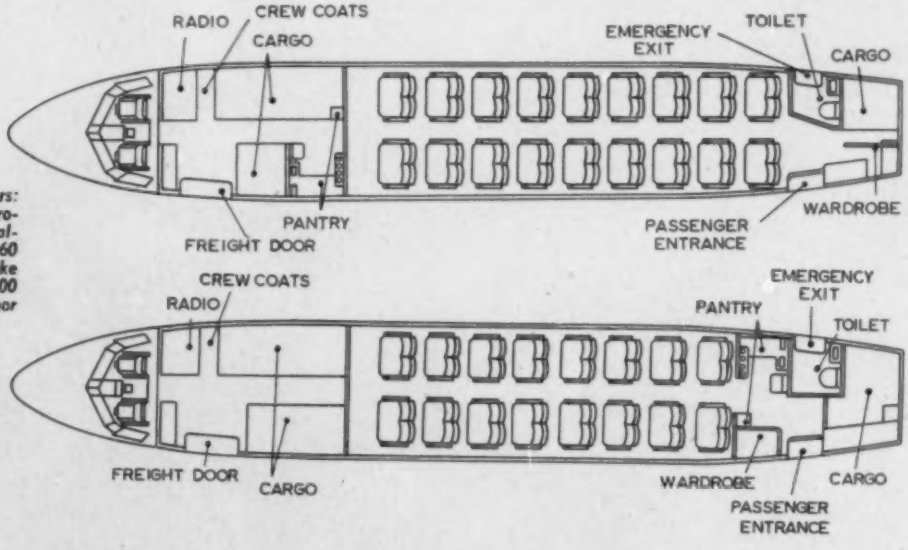
FOKKER F.27 FRIENDSHIP

Two Rolls-Royce Dart 511 of 1,742 e.h.p.

Dimensions: span, 95ft; length, 76ft; height, 27ft 6in; gross wing area, 754 sq ft (aspect ratio 12); track, 23ft 7½in.

Weights: basic operating weight, 21,794 lb; typical maximum payload, 9,416 lb (32 passengers plus 4,000 lb freight); max. zero-fuel weight, 31,210 lb; max. landing weight, 33,000 lb; max. weight, 34,520 lb.

Performance: take-off field length, C.A.R. (see p. 10), 3,800ft; max. cruising speed, 237 kt at 20,000ft; service ceiling, 33,000ft; C.A.R. landing field-length, 3,000ft.



Two typical Friendship interiors: the 36-seat layout (above) provides for cargo forward totalling 137+55 cu ft and for 60 cu ft aft; the 32-seater can take 145+110 cu ft forward and 100 cu ft aft. There is no underfloor hold.

Airliners of the World

HERON

DE HAVILLAND AIRCRAFT CO., LTD., HATFIELD, HERTS.

THE design philosophy of the de Havilland Heron may be summed up very briefly: four-engine safety in an aircraft of a size (14 to 17 passengers) not normally provided with such benefit.

Apart from that, the Heron has the uncommon combination of sturdy simplicity and good short-field performance with the sophistication necessary for all-weather operations. An aircraft in the Heron's category must be equipped to comply with the demands of air traffic control at a main-line terminal; at the same time it must be able to "rough-it" on a desert landing strip.

The primary rôle of the Heron is high-frequency service on local multi-stop networks; in this capacity it serves communities in much the same way as a country bus. It is also, because of its modest size and economy, a proposition for private owner (one half of current sales are to this class of owner).

Airframe Structure. Being a development of the Dove, the Heron incorporates many Dove components. The airframe is entirely of metal, with the exception of the fabric covering of movable surfaces, and stress-bearing skins are attached to stiffeners by the Redux bonding process. The fuselage is built as three main units—nose, cabin and rear fuselage. Each wing is cantilevered from three points, and the upper boom of the main spar is of aluminium alloy, the lower boom being of composite structure: high tensile steel up to the outer engines and aluminium alloy outboard. Flaps and ailerons are hinged on a rear false spar running from root to tip.

The retractable tricycle undercarriage has a castoring self-centring nosewheel with an oleo shock absorber, and the main legs have compression-rubber shock-absorbers. The engines are secured to each wing by four bolts and the bearers, two to each engine, are all interchangeable port and starboard.

Powerplant. The Heron is powered by four de Havilland Gipsy Queen 30 Mk 2 direct-drive unsupercharged piston engines of 250 b.h.p., having six cylinders inverted, in-line, and air cooled. It is a straight development of the well-known Gipsy Six engine of pre-war years. Airscrews are de Havilland two-blade "1,000-size" units incorporating feathering if required. Upward hinging cowlings give complete access to the engines from ground level, and the control runs are accessible via a hinging leading edge.

Cockpit. This is essentially similar to that of the Dove, accommodating two pilots with dual control; the aircraft can be flown by one pilot. The engine throttle and constant-speed airscrew controls are interconnected.

Systems. All flying controls are cable-operated, and access to the full run of all cable is provided. Two 1,000-watt 24-volt generators, one on each outboard engine, supply two accumulators to serve the aircraft electrical system. There are no hydraulics in the Heron; undercarriage retraction, flap operation, wheel-brakes and de-icer boots are operated pneumatically, the system being served by two compressors, one on each outboard engine.

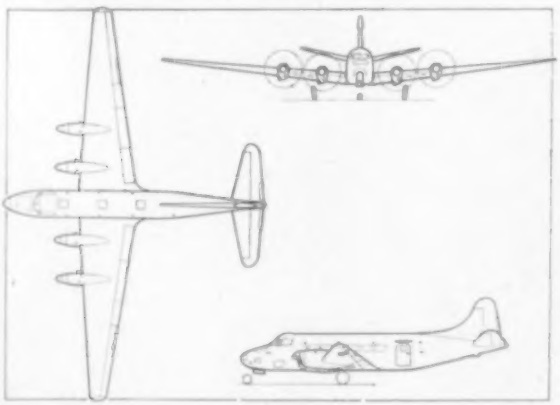
Standard fuel tankage consists of two 102 Imp. gal flexible rubber bag tanks mounted one on each side of the fuselage between the wing spars, replenished from a filler on the upper wing surface. Extra tankage can be provided by mounting a 56 Imp. gal tank forward of each spar. Each engine nacelle includes a nine Imp. gal oil tank. The cabin is air-conditioned by exhaust-heated fresh air, mixed as required with cold air.

A typical radio installation comprises: H.F. and M.F. transmitter-receivers, A.D.F., ten channel V.H.F. transmitter-receiver, and a beam-approach receiver.

Payload Accommodation. The Heron has a cabin 19½ft in length with a head-room of 5ft 8½in. The windows are uncommonly large. The standard aircraft has seats for 14 passengers and provision for a fifteenth seat which may be fitted as required by rearrangement of the toilet and baggage compartments. An alternative version has provision for a further two seats, the inclusion of which reduces baggage space and dispenses with the toilet.

The executive version may be furnished according to individual taste. A typical layout provides accommodation for eight people in large arm-chairs facing each other in pairs, with folding tables between. Each facing pair becomes a couch by the addition of an upholstered squab.

There are two luggage compartments, the forward one being of 22 cu ft, the rear compartment of 105 cu ft.

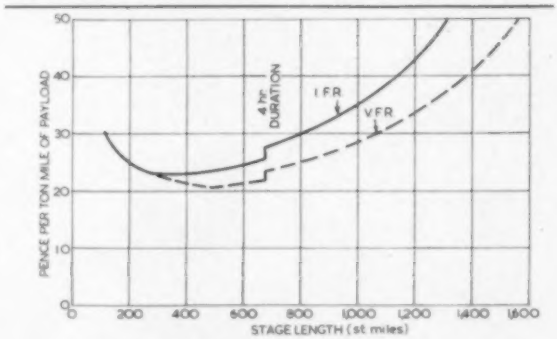


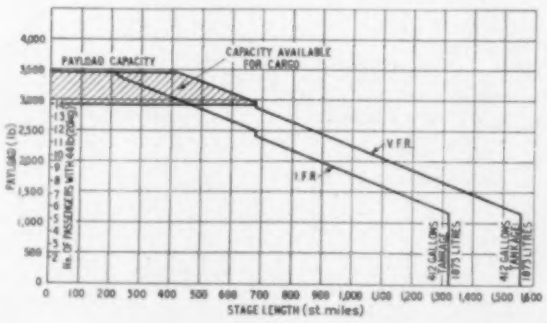
Commercial History. The Heron first flew in May 1950, and the first delivery of a production Heron 1 was in April 1952. All the initial orders placed were for the Series 1 version with the fixed undercarriage, but early in 1952 it was decided to widen the appeal of the aircraft by fitting a retractable undercarriage. The first Series 2, as it was known, flew in December of that year. First production delivery of a Heron 2 was in June 1954, and since then practically all Herons off the production line have been Series 2s, and this is the version currently offered. Feathering airscrews (Series 2D) were first introduced last August and this installation, which exacts only a small penalty in payload (about one passenger), is offered as an optional installation.

Up to the time of closing for press 101 Herons had been delivered, including prototypes and demonstrators. The list of current operators is as follows: New Zealand National Airways, 4; Braathens, 4; Sociedade Agro Insutrial Mineira, 2; Gulf Aviation, 2; U.A.T., 8; Canadian Department of Transport, 1; Jersey Airlines, 7 (including the Series 1 prototype); Garuda, 14; J.H.A.T., 3; B.E.A., 3; Turkish State Airlines, 7; Indian Airlines, 8; West African Airways, 8; Dragon Airways, 3; South African Air Force, 2; Cambrian Airways, 2; Portuguese Ministry of Colonies (Goa), 2; Bahamas Airways, 2; Vickers-Armstrongs, 2; Anglo-American Co. of South Africa, 1; Prince Talal of Saudi Arabia, 1; Governor-General of the Belgian Congo, 1; M.o.S. (B.J.S.M. in Washington), 1; Shell Petroleum, 2; M.o.S. (Queen's Flight), 1; Exchange Yard (South Africa), 1; Canadian Comstock, 1; D. H. Canada, 1.

Dimensions. Span, 71ft 6in; length, 48ft 6in; height, 15ft 7in; track, 16ft 8in; wing area, 499 sq ft.

Weights and Performance (14-passenger non-feathering Series 2E, standard conditions). Gross weight, 13,500 lb; max. landing weight, 13,150 lb; tare weight (no radio), 8,284 lb; payload, 3,223 lb; take-off distance to 50ft, all engines, 810 yd; take-off distance to 50ft, failure of critical engine, 955 yd; landing distance from 50ft, 690 yd; V.F.R. stage-length with capacity payload of 3,460 lb, 510 st. miles; V.F.R. stage-length of 8-seat executive version, 1,260 miles; cruising speed at 65 per cent power, 8,000ft, 183 m.p.h.; service ceiling, 20,000ft.





Airliners of the World

DC-7C SEVEN SEAS

DOUGLAS AIRCRAFT COMPANY, SANTA MONICA, CALIFORNIA

THE philosophy underlying the DC-7C was to exploit, for long-range operations, the power of the Wright Turbo-Compound engine and the proven design features of the DC-7. In June 1954, when the first DC-7C studies were made, the DC-7 had been in service for about eight months. It had been well received by the travelling public and was becoming the most popular transport in domestic U.S. service. Its ability to fly nonstop coast to coast in about eight hours had changed transcontinental travel habits.

Douglas had, in 1953, begun the design of several important changes to the DC-7 to improve range. A new version, to be called the DC-7B, was scheduled for delivery in the spring of 1955. Major changes included "saddle" tanks, which increased fuel capacity by 721 gal; spinners and a new anti-drag ring for better cooling; a new wing-flap mechanism for improved take-off efficiency; larger oil tanks; general structural reinforcement; and higher operating weights.

The DC-7B was well received by the airlines but its major market was still the U.S. domestic one. Its improved range was still not great enough to revise international traffic patterns, such as had been accomplished domestically. Douglas felt that the DC-7B should be improved sufficiently to attain the frequently promised (but never delivered) nonstop all-the-year-round North Atlantic airliner. Studies were made to find the best way to bring this about. These included: (1) Wing-tip tanks. These would have reduced speed 3 to 5 m.p.h., reduced performance, limited maximum take-off weight, and increased ground loads 25 to 50 per cent. Range improvement would have been at the expense of payload. (2) Stalk tanks. These would have had basically the same effect as tip tanks, but would have had more drag. Ground loads would not have been so great but ground-clearance considerations presented problems. Other external tank proposals had similar shortcomings. (3) Extension of wing tips. This would have improved span efficiency and allowed higher take-off weight but would have substantially increased flight and ground loads, and would not permit any appreciable increase in fuel capacity. Thus external fuel would still have been necessary. (4) Extension of wing at root. This solution, which was adopted, permitted higher take-off weight due to span and area increase, room for more than 1,124 gal of additional internal fuel, and —by moving airscrews out 5ft on each side—greatly improved cabin noise and vibration levels. By moving the DC-7B wing outboard, the ground and flight loads were essentially unchanged except in the added wing section.

The latter scheme was adopted despite the fact that the wing-root extension was the most difficult from the manufacturing standpoint of the alternatives available. This modification had to be introduced into the DC-6 and DC-7 production line at a time when that line was producing more than two aircraft a week, yet the DC-7C was out ahead of schedule without delays to normal production deliveries.

Development of the DC-7C followed Douglas tradition in that much "carry-over" from existing aircraft was effected. Significantly, every major change in the DC-7B was included in the DC-7C. Had all these design features not been developed it is probable that the DC-7C could not have been undertaken owing to timing and economic considerations.

However, no compromises were made. The major new changes in the DC-7C included the previously mentioned 10ft wing-root extension, with additional fuel capacity; a 40in fuselage extension; enlargement of the ailerons and flaps; extension of the fin and rudder; a new centre-wing de-icing system; further structural reinforcement; and a series of drag-improvement modifications.

As might be expected, Douglas have been studying domestic uses for the DC-7C (which has become known as the Seven Seas). Despite its long range the aircraft is claimed to have excellent domestic characteristics, including shorter take-off and landing performance than either the DC-6B or DC-7B, improved comfort and economy, and increased flexibility of interior arrangement.

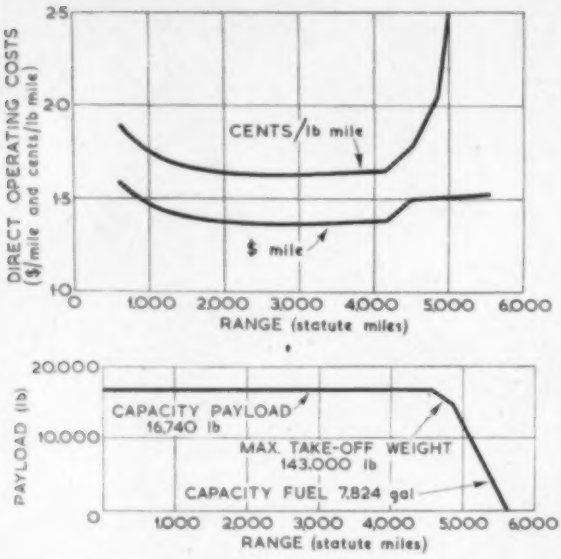
AIRFRAME. The fuselage is of all-metal semi-monocoque construction using light alloys, steel, and titanium, as sheet, extrusion, bar stock, and forgings. The fuselage shell is of conventional skin, stringer and frame construction with transverse floor stiffeners over extruded longitudinal floor supports. Production bolted joints are at the cockpit, aft pressure dome and tail cone. The whole fuselage is designed for a working differential pressure of 5.46 lb/sq in (8,000ft at 25,000ft). Triple-pane windows are fitted throughout the passenger cabin, the inner pane being of the free-floating type.

The wing is of the same basic type of three-spar construction as in the entire DC-6 and DC-7 series. Fuel bag-tanks are fitted inboard of the undercarriage; flexible cells and integral tanks are installed outboard. Ailerons and flaps are all-metal. The tail is essentially the same as that of the DC-7, except that the vertical tail is 24in higher, the horizontal surfaces have greater span and fairings have been added at the rudder hinge cut-outs.

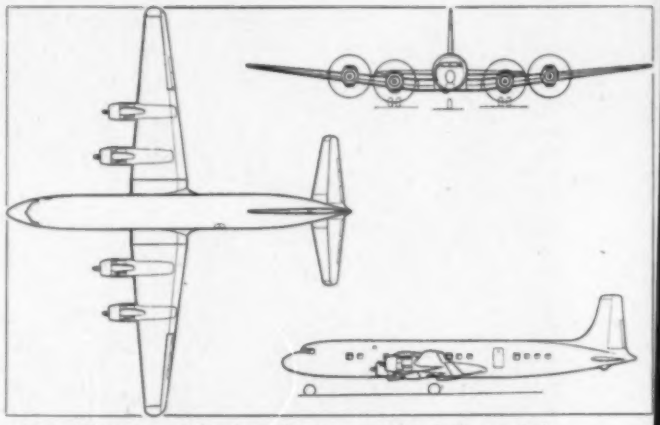
Tubeless tyres (1700 × 20) on Goodyear wheels and brakes are fitted to the main undercarriage gear, which can be dropped independently of the nose unit to act as a speed brake at any i.a.s. The nosewheel has a single 1500 × 16 tubeless tyre on a Goodrich wheel, and is hydraulically steerable to pivot the aircraft about either main leg.

POWERPLANT. Four Wright Turbo-Compound EA-1 series engines drive 34E60-series 14ft four-bladed Hamilton Standard solid dural airscrews. Oil tanks of 47 gal each are fitted. An anti-drag ring has its inner liner inside the cowl entrance for the additional benefit of the airscrew spinner. The mounting is of flash-welded tubes bolted to forging clusters. Inboard and outboard powerplants are identical except for cabin-supercharger drives and hydraulic pumps. Powerplants are quickly removable, being attached by only four 1in-diam. special bolts.

SYSTEMS. Cabin Air. Fresh air is supplied at 5½ lb/sq in by two engine-driven superchargers located in the outboard nacelles providing 112 lb/minute. The air from the superchargers can be directed to a 300,000 B.T.U./hr heater, or through an expansion cooling turbine



Curves for a DC-7C in overwater operation: assumptions are 3 hr reserve fuel plus 15 min, 90 h.p. pressurization load, costs on 1955 A.T.A. revised method.



Airliners of the World

DC-7C

before delivery to the cabin. Certain DC-7s have a closed-circuit Freon system for ground conditioning. Cold air is available at individual seat outlets, and conditioned air at wall "letter-slot" outlets. Air then flows from the cabin to the underfloor compartments, and finally overboard through the cabin pressure control valve or various sonic venturis. Oxygen is provided at each passenger seat, there being a separate system for the crew.

Electrical System. Four engine-driven 400-amp generators provide the basic D.C. current, stored in two 12-volt, 88 amp-hr series-connected batteries. Three inverters provide 400-c.p.s., 115-V, 3-phase current. An emergency busbar is provided with connection to each main generator through individual 200-amp relays.

Hydraulic System. One hydraulic pump on each inboard engine provides power at approximately 3,000 lb/sq in to operate the following units: undercarriage retraction and extension, nosewheel steering, windscreen wipers, wheelbrakes, and flaps. The system consists of the following major items in addition to the pumps mentioned above: a 4.5 gal reservoir; a by-pass valve and control, pressure regulator, pressure accumulator and an electrically operated emergency pump.

Fuel System. The basic DC-7B eight-tank (one main and one alternate tank for each engine) fuel system has been expanded to 6,515 gal. A "transistorized" fuel-quantity indicating system has been used.

De-icing System. Wing and tail de-icing are essentially the same as the DC-6 and DC-7 series, except for the additional five feet of inboard wing. This area, together with the rest of the wing span inboard of the inner nacelles, is not de-iced during the time that the remainder of the wing is being de-iced. When the icing condition is passed, heat can then be directed, by a handle in the cockpit, to the inner wing area to clear it of any accumulated ice. A third position of the cockpit handle reduces airflow through the wing and tail to that required for adequate ventilation, thereby reducing airflow drag when de-icing is not required.

Flight Deck. Cockpit layout is basically the same as that of the DC-7 series, except for aileron-wheel throw which is increased from 90 deg to 110 deg. De-icing control for the inboard wing has been added as well as a cabin outflow air-valve control.

Flying Controls. This is basically the same as the DC-7 system. All movable surfaces have aerodynamic tabs; the port aileron has a cable-driven trim tab, the elevators have spring trim tabs, and rudder trim is by spring force on the main control system. The flap system is hydraulically operated and mechanically "bussed."

Radio and Radar. The basic radio consists of duplicated H.F., V.H.F., V.O.R., A.D.F., a marker beacon, glide slope, radio altimeter, Loran, A-12 autopilot, intercommunication and a public-address system. Either R.C.A. or Bendix cloud warning radar is available, in a hot-air de-iced radome. There is provision for radar scopes at the pilot's, co-pilot's and/or navigator's station.

PAYLOAD ACCOMMODATION. The DC-7C can have a variety of interior arrangements. The standard 62-passenger arrangement, which is not precisely the same as any existing customer's configuration, comprises three cabin compartments with eight "dayplane" seats in the "state-room" compartment, 38 dayplane seats in the main compartment, and 16 berth seats in the aft compartment. Two toilets are provided at the aft end of the rear compartment, with two additional toilets between the main passenger compartment and stateroom. The galley facilities consist of a large main galley section just forward of the main passenger door, and an aft buffet just aft of the main passenger door. Opposite this is a large wardrobe and magazine rack, and a double stewardess seat mounted just forward of the wardrobe. The aft cabin has four upper berths and in addition the 16 seats can be made into four berths. Life-rafts are carried in an upper berth type of compartment on the right-hand side of the cabin just ahead of the wardrobe.

The entire main cabin can be made "berthable," and removable berths are available which can be alternated with hat racks. An upper berth can be provided on the right-hand side of the forward stateroom. All seats are mounted on tracks, and the seat pitch, as well as the type of seat, can be changed quickly. Removable bulkheads are available which divide the main cabin into virtually any combination of first-class and tourist seating, with first-class seating to the rear (the aft cabin is usually the last compartment to be made into a tourist arrangement). The forward state-room can be enlarged to take 12 passengers by removing the crew bunk area on routes where crew sleeping accommodation is not required.

A removable lounge can be installed opposite the door in the area occupied by the wardrobe and stewardess station. Luggage and cargo space is provided below the floor and is accessible from outside. The forward lower hold provides 312 cu ft, and the aft hold has a capacity of 339 cu ft. These compartments have weight limited capacities of 6,600 lb and 6,840 lb respectively. The forward state-room is readily convertible to a cargo compartment of 303 cu ft (with crew sleeping space) up to a limit of 4,660 lb.

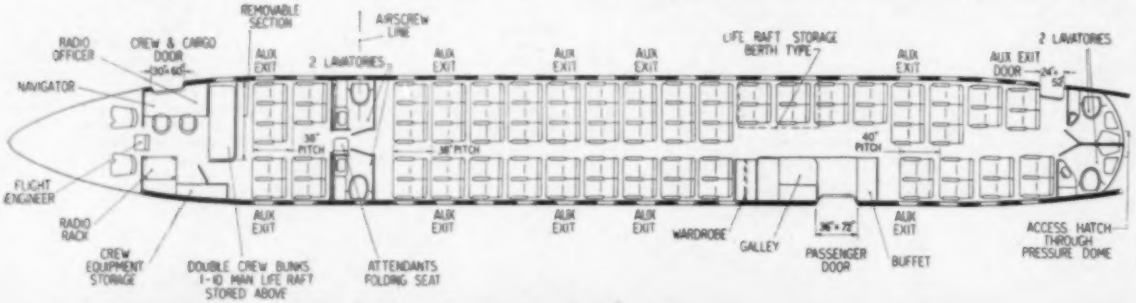
Weights and Performance. Max. take-off weight, 143,000 lb; max. landing weight, 109,000 lb; max. zero fuel weight, 101,500 lb; empty weight, 73,400 lb; capacity payload, 22,590 lb; total fuel tankage, 7,824 U.S. gal.; C.A.A. take-off distance at 140,000 lb, sea level, 5,920 ft; C.A.A. landing distance at 109,000 lb sea level, 5,450ft; absolute* range at 23,500ft with 1,800 b.h.p./engine, 5,440 st. miles; average cruising speed for above range, 340 m.p.h.; absolute* range at 1,500ft at 1.1V L/D, 5,995 st. miles; average speed for above range, 274 m.p.h.

*No allowance for warm-up, taxi, take-off, climb, manoeuvre, or reserve fuel. See payload-range chart for operational values of range, speed, payload and cost. Additional data is given on page 54.

COMMERCIAL HISTORY. The predecessors of the DC-7C, from which it has been evolved, are as follows.

DC-6. This aircraft, first delivered in 1946, was originally designed for domestic U.S. operation and medium-range overseas service using Pratt and Whitney R-2800 CA engines. Operating weights were initially 84,000 lb take-off and 73,000 lb landing. Ultimately the DC-6 reached 97,200 lb and 80,000 lb, respectively. The cabin was pressurized for 8,000ft at 20,000ft altitude. Fuel capacity varied from 2,765 gal to 3,537 gal, later being increased to 3,932 gal. A total of 175 DC-6s were built.

DC-6A. This was a cargo version of the DC-6, with higher weights and with special cargo doors and floors and fuselage extended by 5ft. It was pressurized for 8,000ft at 20,000ft altitude, and had R-2800 CB series engines of 2,500 h.p. each. It flew in 1949 and the first was delivered in 1951. Take-off weight was raised to 107,000 lb, landing



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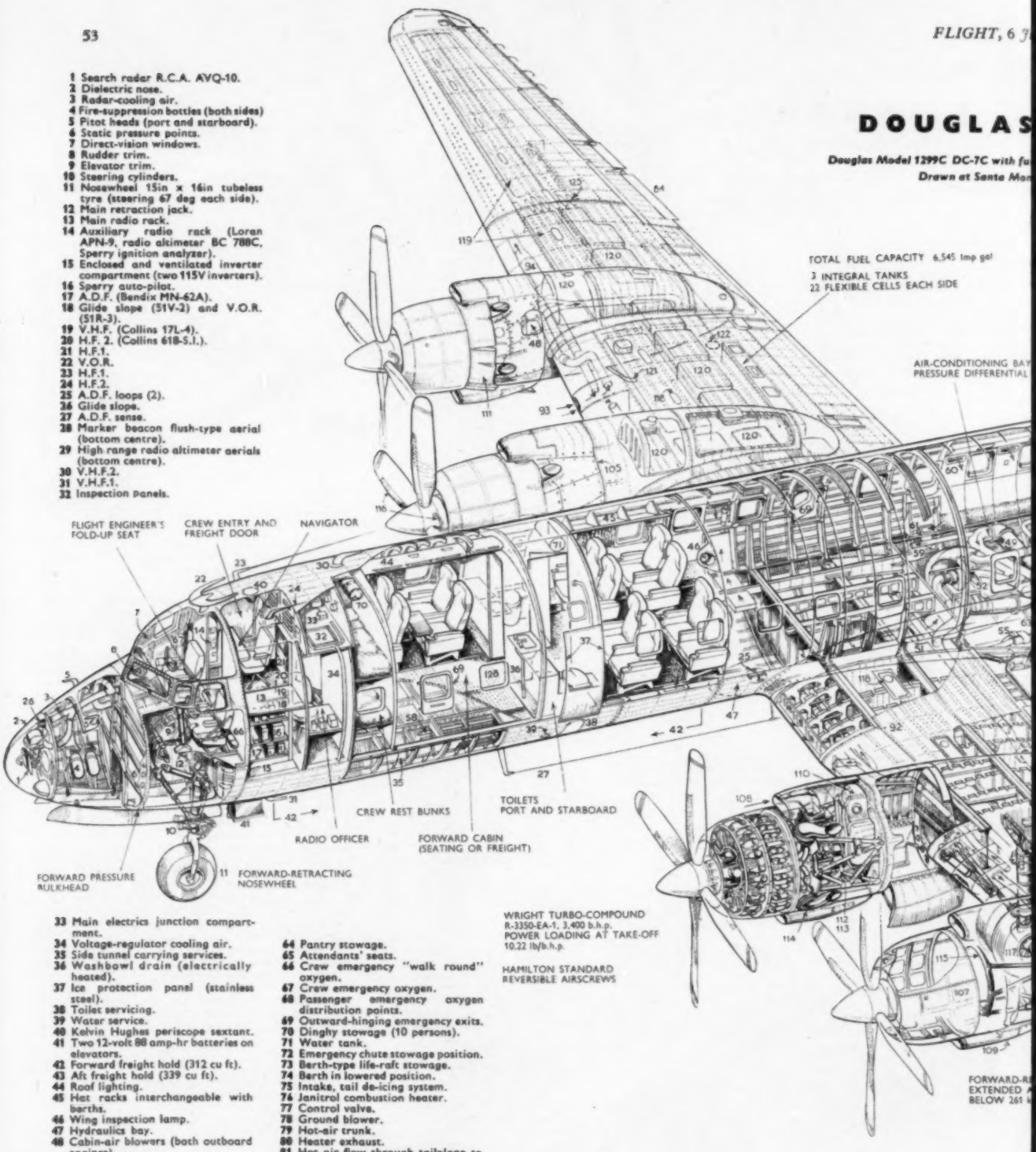

1 Search radar R.C.A. AVQ-10.
2 Dielectric nose.
3 Radar-cooling air.
4 Fire-suppression bottles (both sides)
5 Pitot heads (port and starboard).
6 Static pressure points.
7 Direct-vision windows.
8 Rudder trim.
9 Elevator trim.
10 Steering cylinders.
11 Nosewheel 15in x 16in tubeless tyre (steering 67 deg each side).
12 Main retraction jack.
13 Main radio rack.
14 Auxiliary radio rack (Loran APN-9, radio altimeter BC 788C, Sperry ignition analyzer).
15 Enclosed and ventilated inverter compartment (two 115V inverters).
16 Sperry auto-pilot.
17 A.D.F. (Bendix MN-62A).
18 Glide slope (51V-2) and V.O.R. (51R-3).
19 V.H.F. (Collins 17L-4).
20 H.F. 2. (Collins 618-S.I.).
21 H.F.1.
22 V.O.R.
23 H.F.1.
24 H.F.2.
25 A.D.F. loops (2).
26 Glide slope.
27 A.D.F. sense.
28 Marker beacon flush-type aerial (bottom centre).
29 High range radio altimeter aerials (bottom centre).
30 V.H.F.2.
31 V.H.F.1.
32 Inspection panels.
33 Main electrics junction compartment.
34 Voltage-regulator cooling air.
35 Side tunnel carrying services.
36 Washbowl drain (electrically heated).
37 Ice protection panel (stainless steel).
38 Toilet servicing.
39 Water service.
40 Kelvin Hughes periscope sextant.
41 Two 12-volt 88 amp-hr batteries on elevators.
42 Forward freight hold (312 cu ft).
43 Aft freight hold (339 cu ft).
44 Roof lighting.
45 Hat racks interchangeable with berths.
46 Wing inspection lamp.
47 Hydraulics bay.
48 Cabin-air blowers (both outboard engines).
49 Janitrol combustion heater.
50 Heating air mixing valves.
51 Under-belly coolant air-scoop.
52 Cooling turbine.
53 Ground blower and recirculating fan.
54 Ground blower intake.
55 Heater ground blower.
56 Individual cold air to inboard passenger.
57 Individual cold air to outboard passenger.
58 Cockpit hot air.
59 Windscreen anti-icing hot air.
60 Main conditioned air in.
61 Cabin exhaust.
62 Cabin-air control canister.
63 Combustion heater exhaust.
64 Pantry stowage.
65 Attendants' seats.
66 Crew emergency "walk round" oxygen.
67 Crew emergency oxygen.
68 Passenger emergency oxygen distribution points.
69 Outward-hinging emergency exits.
70 Dinghy stowage (10 persons).
71 Water tank.
72 Emergency chute stowage position.
73 Berth-type life-raft stowage.
74 Berth in lowered position.
75 Intake, tail de-icing system.
76 Janitrol combustion heater.
77 Control valve.
78 Ground blower.
79 Hot-air trunk.
80 Heater exhaust.
81 Hot air flow through tailplane to exhaust over elevators (fin and rudder similar).
82 Fabric covered rudder.
83 Provision for flares.
84 Trim tabs.
85 Control tabs.
86 Elevator tip hinge.
87 Revolving red anti-collision light.
88 Tailplane and elevators interchangeable, port and starboard.
89 Shock-absorbing bumper.
90 Cat walk.
91 Elevator control.
92 No skin or spar break at change of dihedral.
93 Plenum chamber supplying air to cabin system and de-icing.
94 Wing de-icing combustion heater.
95 Wing de-icing hot air trunk.
96 Hot air baffle.
97 Corrugated inner skin.
98 Hot-air outlet (upper and lower surfaces).
99 Combustion heater exhaust.
100 Glass-fibre trailing edge.
101 Aileron control.
102 Flap actuators.
103 Nacelle section moves with flap.
104 Flap synchronizing links.
105 Titanium fire-wall and nacelle structure.
106 Production break joint.
107 Cowlings removed in three sections for engine service.
108 Carburettor intake.
109 Oil cooler.
110 Oil tank 45.8 gal (2½ gal for feathering).
111 Controllable gills.
112 Alternators on inboard engines (Eclipse 115V) emergency A.C. supply.
113 Generators on all engines (G.E. 30V 480 amp).
114 Power recovery turbines.
115 Engine mounting ring.
116 Cyclic electric de-icing.
117 Tubeless tyres 17.00in x 20in; hydraulic brakes (pressure reduced from main 3,000 lb/sq in system).
118 Fuel ta
119 Integra
120 Bag ty
121 Retract nacelle
122 Landin (600 W
123 Fuel va
124 Sliding age.
125 Bolt-th joint.
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128 Windo

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Douglas Model 1299C DC-7C with fur
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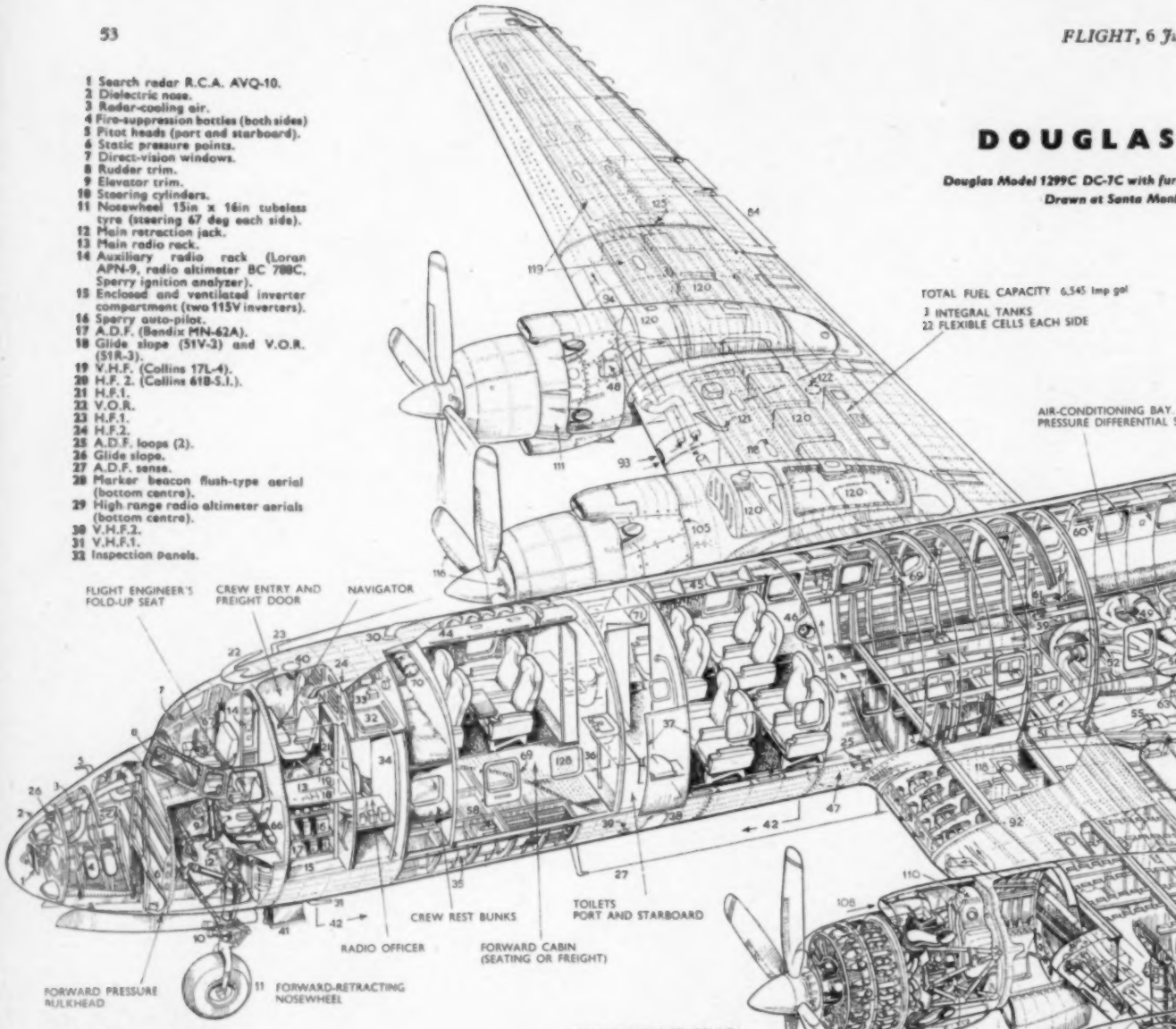

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125 Bolt-thro joint.
126 "Door op
127 Refrigera
128 Windows

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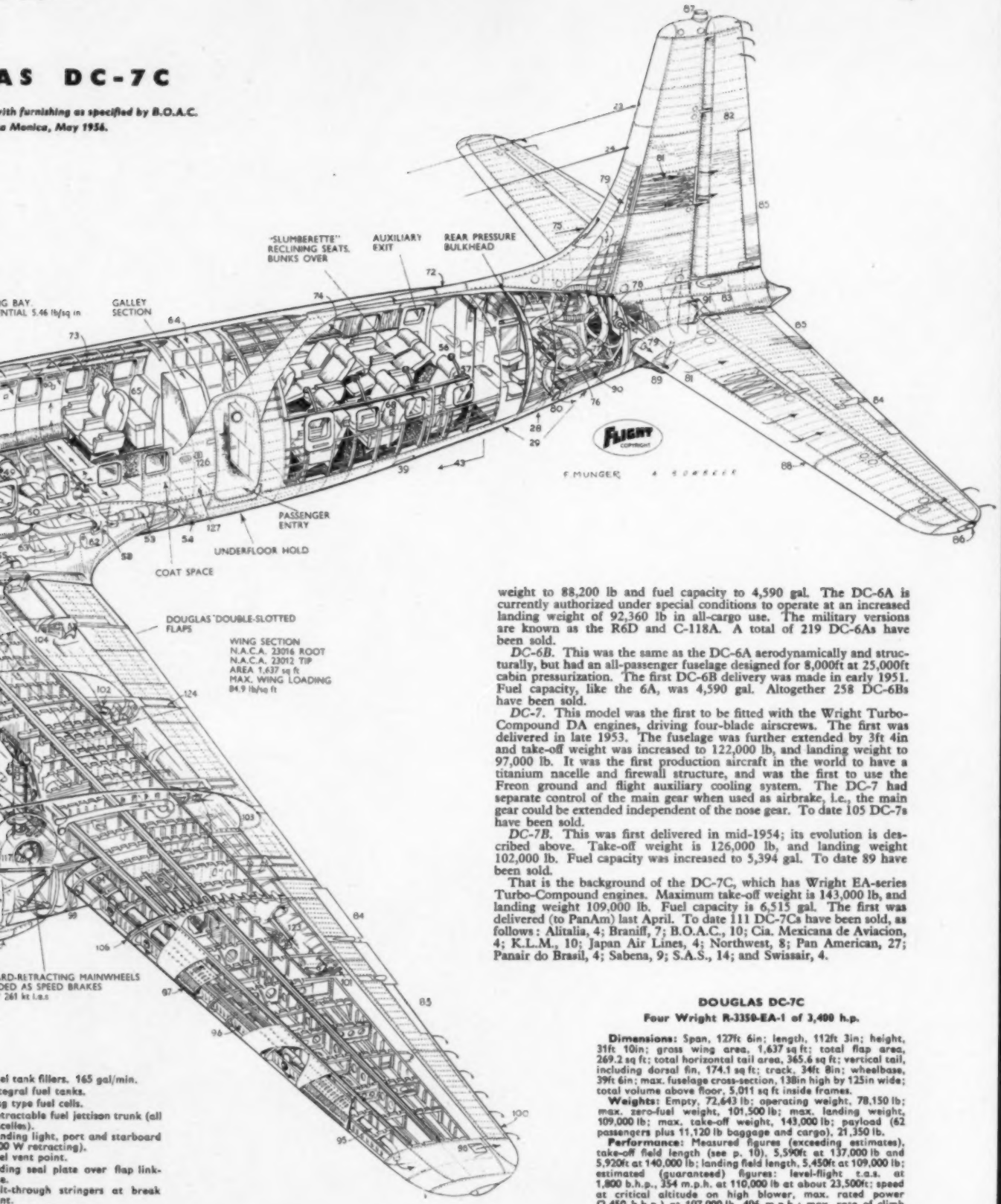
a Monica, May 1956.



weight to 88,200 lb and fuel capacity to 4,590 gal. The DC-6A is currently authorized under special conditions to operate at an increased landing weight of 92,360 lb in all-cargo use. The military versions are known as the R6D and C-118A. A total of 219 DC-6As have been sold.

DC-6B. This was the same as the DC-6A aerodynamically and structurally, but had an all-passenger fuselage designed for 8,000ft at 25,000ft cabin pressurization. The first DC-6B delivery was made in early 1951. Fuel capacity, like the 6A, was 4,590 gal. Altogether 258 DC-6Bs have been sold.

DC-7. This model was the first to be fitted with the Wright Turbo-Compound DA engines, driving four-blade airscrews. The first was delivered in late 1953. The fuselage was further extended by 3ft 4in and take-off weight was increased to 122,000 lb, and landing weight to 97,000 lb. It was the first production aircraft in the world to have a titanium nacelle and firewall structure, and was the first to use the Freon ground and flight auxiliary cooling system. The DC-7 had separate control of the main gear when used as airbrake, i.e., the main gear could be extended independent of the nose gear. To date 105 DC-7s have been sold.

DC-7B. This was first delivered in mid-1954; its evolution is described above. Take-off weight is 126,000 lb, and landing weight 102,000 lb. Fuel capacity was increased to 5,394 gal. To date 89 have been sold.

That is the background of the DC-7C, which has Wright EA-series Turbo-Compound engines. Maximum take-off weight is 143,000 lb, and landing weight 109,000 lb. Fuel capacity is 6,515 gal. The first was delivered (to PanAm) last April. To date 111 DC-7Cs have been sold, as follows: Alitalia, 4; Braniff, 7; B.O.A.C., 10; Cia. Mexicana de Aviacion, 4; K.L.M., 10; Japan Air Lines, 4; Northwest, 8; Pan American, 27; Panair do Brasil, 4; Sabena, 9; S.A.S., 14; and Swissair, 4.

DOUGLAS DC-7C

Four Wright R-3350-EA-1 of 3,400 h.p.

Dimensions: Span, 127ft 6in; length, 112ft 3in; height, 31ft 10in; gross wing area, 1,637 sq ft; total flap area, 269.2 sq ft; total horizontal tail area, 365.6 sq ft; vertical tail, including dorsal fin, 174.1 sq ft; track, 34ft 8in; wheelbase, 39ft 6in; max. fuselage cross-section, 13Bin high by 125in wide; total volume above floor, 5,011 sq ft inside frames.

Weights: Empty, 72,643 lb; operating weight, 78,150 lb; max. zero-fuel weight, 101,500 lb; max. landing weight, 109,000 lb; max. take-off weight, 143,000 lb; payload (62 passengers plus 11,120 lb baggage and cargo), 21,350 lb.

Performance: Measured figures (exceeding estimates), take-off field length (see p. 10), 5,590ft at 137,000 lb and 5,920ft at 140,000 lb; landing field length, 5,450ft at 109,000 lb; estimated (guaranteed) figures: level-flight c.a.s. at 1,800 b.h.p., 354 m.p.h. at 110,000 lb at about 23,500ft; speed at critical altitude on high blower, max. rated power (2,450 b.h.p.) at 107,000 lb, 406 m.p.h.; max. rate of climb at 20,000ft at 107,000 lb with rated power, 845ft/min; second-segment climb at 139,000 lb with one airscrew feathered, 645ft/min at 500ft with 10 deg flap.

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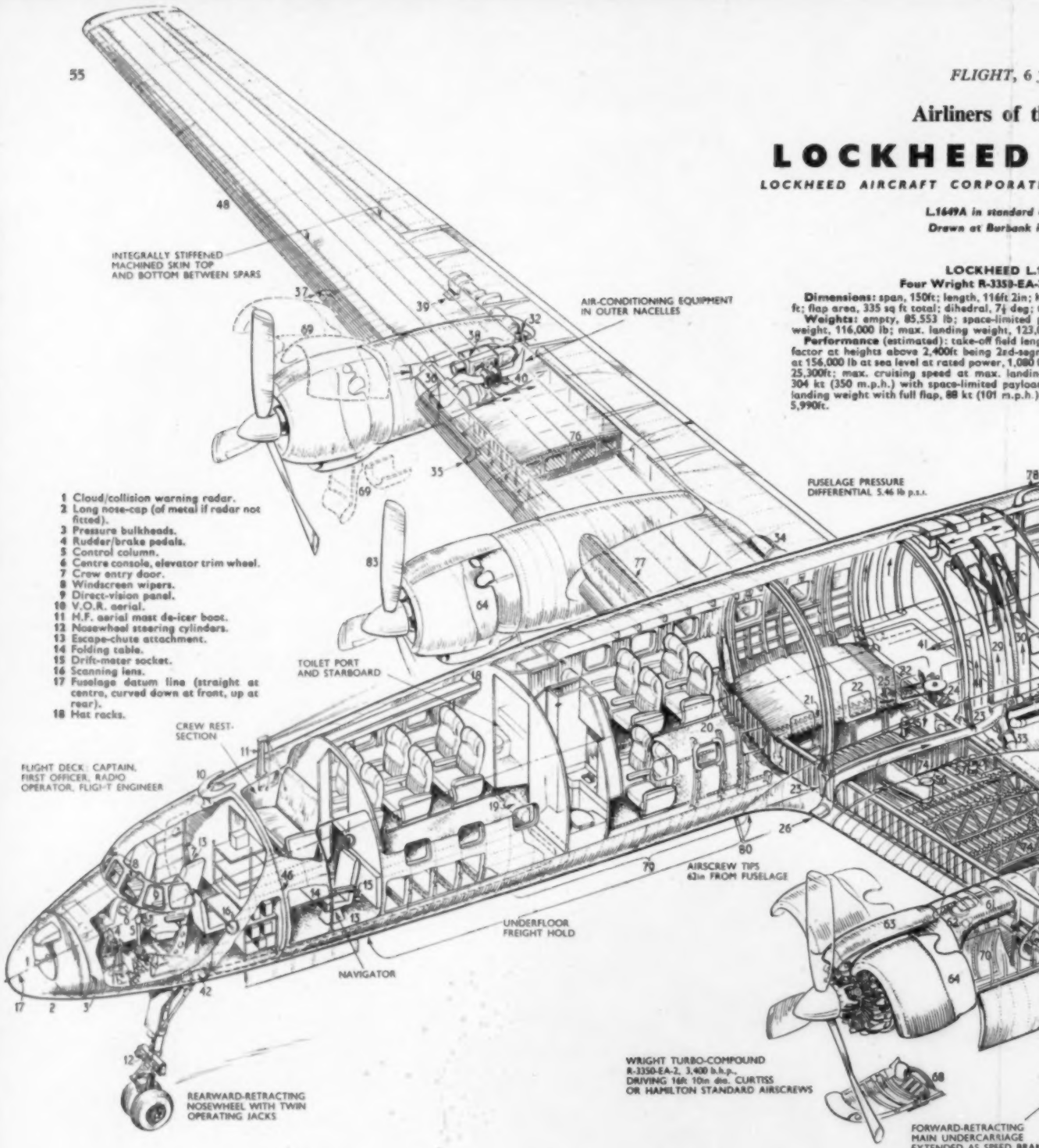
LOCKHEED

LOCKHEED AIRCRAFT CORPORAT

L.1649A in standard
Drawn at Burbank

LOCKHEED L.
Four Wright R-3350-EA-

Dimensions: span, 150ft; length, 116ft 2in; h
ft; flap area, 335 sq ft total; dihedral, 7½ deg;
Weights: empty, 85,553 lb; space-limited
weight, 116,000 lb; max. landing weight, 123,
Performance (estimated): take-off field leng
factor at heights above 2,400ft being 2nd-segr
at 156,000 lb at sea level at rated power, 1,080
25,300ft; max. cruising speed at max. landin
304 kt (350 m.p.h.) with space-limited payloa
landing weight with full flap, 88 kt (101 m.p.h.)
5,990ft.


INTEGRALLY STIFFENED MACHINED SKIN TOP AND BOTTOM BETWEEN SPARS
AIR-CONDITIONING EQUIPMENT IN OUTER NACELLES
FUSELAGE PRESSURE DIFFERENTIAL 5.46 lb p.s.i.
TOILET PORT AND STARBOARD
CREW REST-SECTION
FLIGHT DECK: CAPTAIN, FIRST OFFICER, RADIO OPERATOR, FLIGHT ENGINEER
AIRSCREW TIPS 62in FROM FUSELAGE
UNDERFLOOR FREIGHT HOLD
NAVIGATOR
WRIGHT TURBO-COMPOUND R-3350-EA-2, 3,400 b.h.p., DRIVING 16ft 10in dia. CURTISS OR HAMILTON STANDARD AIRSCREWS
REARWARD-RETRACTING NOSEWHEEL WITH TWIN OPERATING JACKS
FORWARD-RETRACTING MAIN UNDERCARRIAGE EXTENDED AS SPEED BRA
BELOW 233 kt i.a.s.

1 Cloud/collision warning radar.
2 Long nose-cap (of metal if radar not fitted).
3 Pressure bulkheads.
4 Rudder/brake pedals.
5 Control column.
6 Centre console, elevator trim wheel.
7 Crew entry door.
8 Windscreen wipers.
9 Direct-vision panel.
10 V.O.R. aerial.
11 H.F. aerial mast de-icer boot.
12 Nosewheel steering cylinders.
13 Escape-chute attachment.
14 Folding table.
15 Drift-meter socket.
16 Scanning lens.
17 Fuselage datum line (straight at centre, curved down at front, up at rear).
18 Hat racks.
19 Flight-deck conditioned-air booster fan.
20 End of sloping floor, front cabin.
21 Centre-line butt strap joining wing halves.
22 Emergency exits.
23 Wing/fuselage joint forged fittings.
24 Aileron booster unit (also integrates autopilot, no motors).
25 Pilots' input cables to 24.
26 Auxiliary vent air inlet.
27 Heater unit (starboard identical).
28 Combustion heater exhaust.
29 Cabin-air riser and roof duct.
30 Hot wall panelling riser and duct.
31 Fresh-air inlet.
32 Air mixing valve.
33 Cold air restrictor valve.
34 Water separator.
35 Intake to cabin blower.
36 Primary heat exchanger.
37 Intake to 36.
38 Secondary heat exchanger and hydraulic fan.
39 Intake to 38.
40 Air cycle unit.
41 Cold air riser and distribution ducts.
42 Flight station auxiliary heater.
43 Cabin pressure relief valve.
44 Inward relief valve.
45 Auxiliary ventilation exit valve.
46 Production break-line.
47 Elevator mass-balance.
48 Pneumatic de-icer boots.
49 Rudder booster unit (also integrates autopilot, no motors).
50 Rudder interconnecting linkage.
51 Fabric-covered rudders.
52 Elevator booster unit (also integrates autopilot, no motors).
53 Trim tabs.
54 Whole tail unit similar to 1049, but strengthened.
55 Doors locked by multiple bolts linked to single handle.
56 Centre-section fuel-tank filler.
57 Booster pumps.
58 Bonded beaded skin on flap shroud.
59 Flap tracks and rollers (other three flap sections similar).
60 Flap actuators (screw-jacks driven by shafting from hydraulic motors).
61 Engine oil tank (inners shaped to fit retracted wheels).
62 "Full flow" oil filters.
63 Centre cowl beam and carburettor air intake.
64 Adjustable gills.
65 Power-recovery turbines (three per engine).
66 Firewall.
67 Airflow through oil cooler.
68 Bottom cowl shown detached.
69 Other cowl positions.
70 Wheel bay (fo undercarriage)
71 Alcohol tank (both outer na
72 Break-line betw flap sections.
73 Aileron final l (24).
74 Tank end-ribs.
75 Integral skin lattice ribs.
76 Typical wing integrally stiff panels.

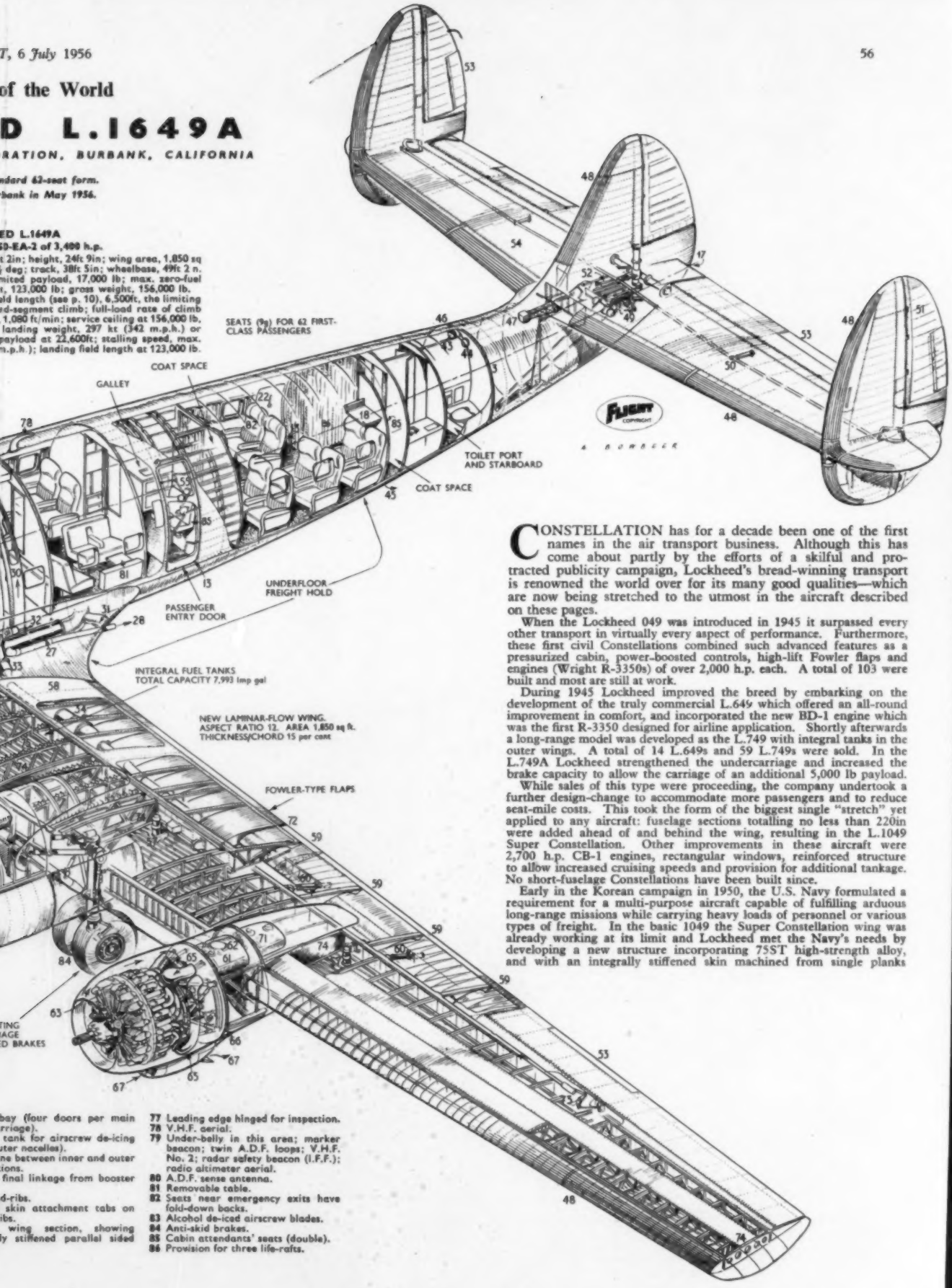
of the World

D L.1649A

RATION, BURBANK, CALIFORNIA

ndard 62-seat form.
bank in May 1956.

ED L.1649A
50-EA-2 of 3,400 h.p.
t 2in; height, 24ft 9in; wing area, 1,850 sq
deg; track, 38ft 5in; wheelbase, 49ft 2 n.
mited payload, 17,000 lb; max. zero-fuel
t, 123,000 lb; gross weight, 156,000 lb.
ld length (see p. 10), 6,500ft, the limiting
d-segment climb; full-load rate of climb
1,080 ft/min; service ceiling at 156,000 lb,
landing weight, 297 kt (342 m.p.h.) or
payload at 22,600ft; stalling speed, max.
n.p.h.); landing field length at 123,000 lb.


SEATS (99) FOR 62 FIRST-CLASS PASSENGERS
COAT SPACE
GALLEY
TOILET PORT AND STARBOARD
COAT SPACE
UNDERFLOOR FREIGHT HOLD
PASSENGER ENTRY DOOR
INTEGRAL FUEL TANKS TOTAL CAPACITY 7,993 Imp gal
NEW LAMINAR-FLOW WING. ASPECT RATIO 12. AREA 1,850 sq ft. THICKNESS/CHORD 15 per cent
FOWLER-TYPE FLAPS
FLIGHT COPYRIGHT
A BOMBER

CONSTELLATION has for a decade been one of the first names in the air transport business. Although this has come about partly by the efforts of a skilful and protracted publicity campaign, Lockheed's bread-winning transport is renowned the world over for its many good qualities—which are now being stretched to the utmost in the aircraft described on these pages.

When the Lockheed 049 was introduced in 1945 it surpassed every other transport in virtually every aspect of performance. Furthermore, these first civil Constellations combined such advanced features as a pressurized cabin, power-boosted controls, high-lift Fowler flaps and engines (Wright R-3350s) of over 2,000 h.p. each. A total of 103 were built and most are still at work.

During 1945 Lockheed improved the breed by embarking on the development of the truly commercial L.649 which offered an all-round improvement in comfort, and incorporated the new BD-1 engine which was the first R-3350 designed for airline application. Shortly afterwards a long-range model was developed as the L.749 with integral tanks in the outer wings. A total of 14 L.649s and 59 L.749s were sold. In the L.749A Lockheed strengthened the undercarriage and increased the brake capacity to allow the carriage of an additional 5,000 lb payload.

While sales of this type were proceeding, the company undertook a further design-change to accommodate more passengers and to reduce seat-mile costs. This took the form of the biggest single "stretch" yet applied to any aircraft: fuselage sections totalling no less than 220in were added ahead of and behind the wing, resulting in the L.1049 Super Constellation. Other improvements in these aircraft were 2,700 h.p. CB-1 engines, rectangular windows, reinforced structure to allow increased cruising speeds and provision for additional tankage. No short-fuselage Constellations have been built since.

Early in the Korean campaign in 1950, the U.S. Navy formulated a requirement for a multi-purpose aircraft capable of fulfilling arduous long-range missions while carrying heavy loads of personnel or various types of freight. In the basic 1049 the Super Constellation wing was already working at its limit and Lockheed met the Navy's needs by developing a new structure incorporating 75ST high-strength alloy, and with an integrally stiffened skin machined from single planks

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tank for airscrew de-icing
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ne between inner and outer
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final linkage from booster

d-ribs.
skin attachment tabs on
ibs.
wing section, showing
ly stiffened parallel sided

77 Leading edge hinged for inspection.
78 V.H.F. aerial.
79 Under-belly in this area; marker beacon; twin A.D.F. loops; V.H.F. No. 2; radar safety beacon (I.F.F.); radio altimeter aerial.
80 A.D.F. sense antenna.
81 Removable table.
82 Seats near emergency exits have fold-down backs.
83 Alcohol de-iced airscrew blades.
84 Anti-skid brakes.
85 Cabin attendants' seats (double).
86 Provision for three life-rafts.

f the World

D L.1649A

RATION, BURBANK, CALIFORNIA

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D L.1649A
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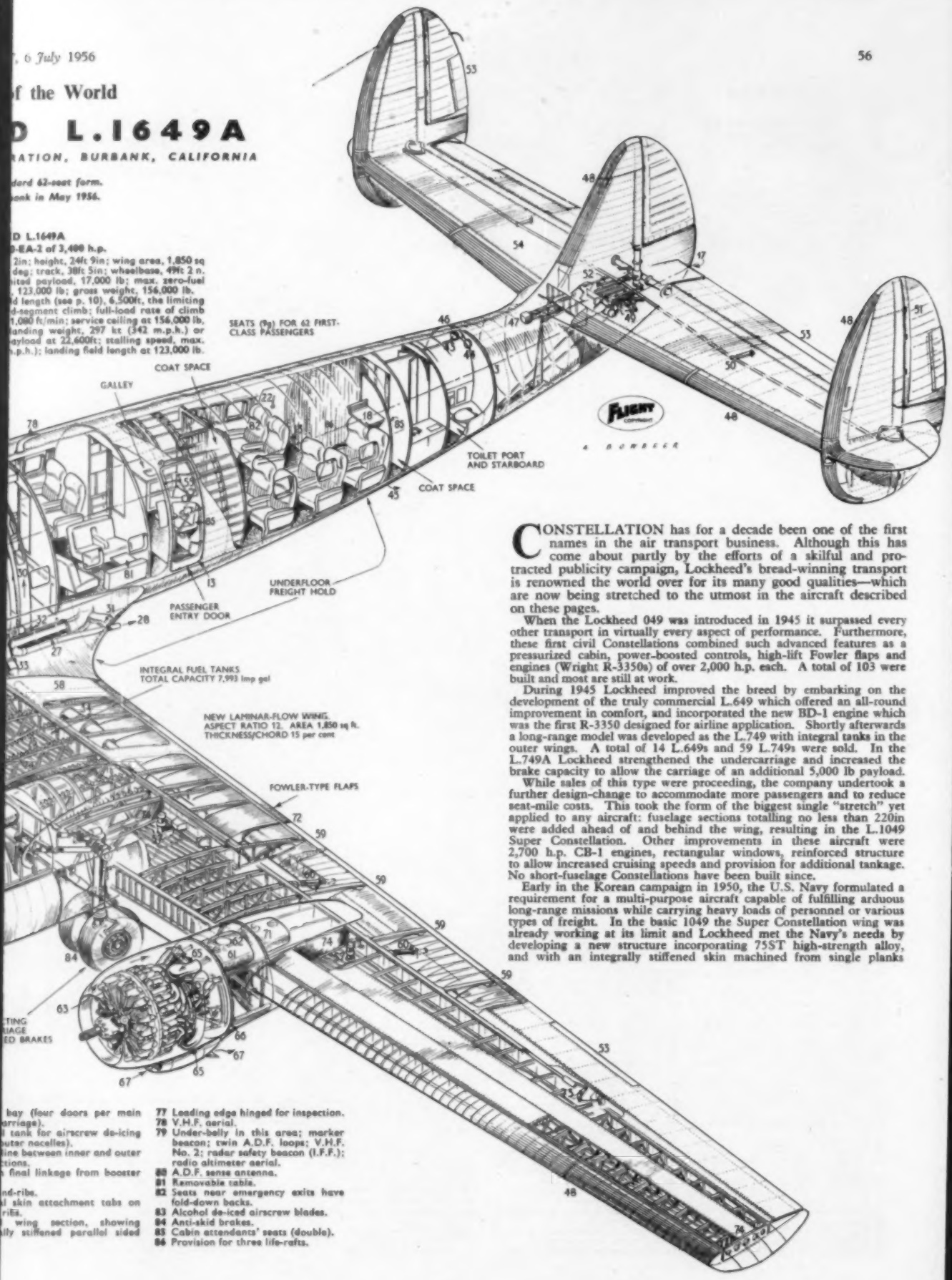

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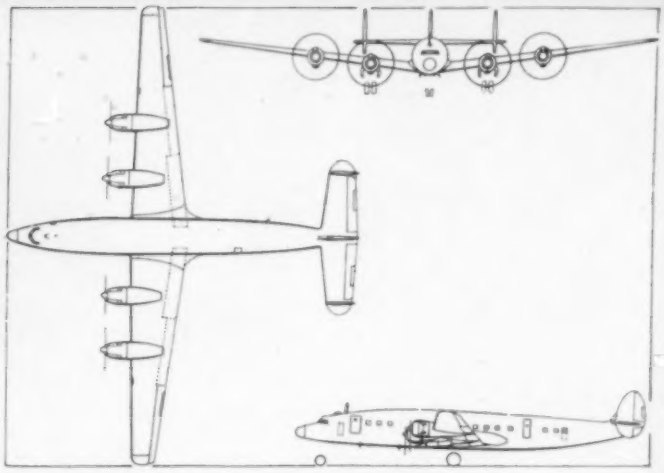


between the spars on the underside of the wing. With a minimum increase in structure weight the new wing allowed the maximum weight to go up to 130,000 lb (later 133,000 lb), the maximum landing and zero-fuel weights being set at 110,000 lb and 105,000 lb respectively.

To match these ambitious figures the Turbo-Compound version of the R-3350 was installed, with a take-off rating of 3,250 h.p. Initially, the flames from the power-recovery turbines in these engines reached the wing trailing edge under climbing conditions, but Lockheed and Wright eventually reduced the pyrotechnic trouble to a point at which it can no longer alarm passengers. These changes opened the way to a new family of heavier and more powerful aircraft.

Production of a large number of military multi-purpose transports led to the L.1049D, which can fairly be considered the first specialized long-range commercial freighter. Particular features of these aircraft are the cargo doors (112½in × 74½in forward and 61½in × 76½in aft) and a floor made of extruded, integrally stiffened magnesium planks stressed to an overall loading of 300 lb/sq ft; the whole interior is sealed to allow the aircraft to be hosed down after carrying dirty loads. Apart from their use as military and commercial freighters, many similar aircraft have been supplied to the American Services equipped as high-altitude radar pickets carrying six tons of radar and 7,290 gal of fuel.

Meanwhile, production of the 1049C passenger airliner was put in hand. In this aircraft the weight and performance advantages of the integral-skin wing and Turbo-Compound engine were combined with a luxurious Dreyfuss-styled interior. In the 1049E the gross weight was increased to 135,400 lb and the Turbo-Compound DA-1 engine (in which detail improvements allowed increased ratings to be established) led to the 1049G at 137,500 lb. Several of the operators of the latter have bought "Super-G" aircraft with 500-gal fuel tanks mounted on the wing tips. In the latest aircraft of this series the zero-fuel weight has been raised to 108,000 lb. A multi-purpose cargo version of the G is the L.1049H, at the same weight.

Since 1952 Lockheed have intensively investigated the potentialities of turboprop power. In particular, an exhaustive study was made of projected Super Constellations powered by the Pratt and Whitney T34 engine of 5,500 to 6,000 h.p. Examples of such aircraft were built for evaluation by the U.S.A.F. and Navy and have since established remarkable records for all-round performance. Experience with such powerful engines led to considerable engineering effort being applied to the development of such projects as the L.1249, 1449 and 1549, in which four Pratt and Whitney PT-2 turboprops (commercial T34s) were matched to various forms of Super Constellation airframe. Eventually, however, it was decided to stay piston-powered and to go all-out for extreme range, and this was done under the project number L.1649 (now L.1649A).

In this aircraft the latest and most powerful commercial Turbo-Compound engines are linked with a completely new wing into which Lockheed have poured every ounce of their ingenuity and ability, to give what is probably the most efficient long-range aerofoil in the world. Quite apart from its remarkable structure, which is described below, the new wing has a greater span and aspect ratio than that of any other long-range transport and has reduced thickness (t/c is 15 per cent at the root, compared with 18 in the 1049) and a profile giving laminar flow to a point well back on the chord. The total drag coefficient has been reduced from 0.0208 in the L.1049 to 0.0166 in the L.1649A. Apart from this remarkable wing the new aircraft is substantially re-engineered in several important respects, and in many cases runs exactly parallel to its stable-mates the C-130 and the Electra, particularly as regards the engineering of its power systems and services.

AIRFRAME. The impression created by the L.1649 is that Lockheed have wrung the utmost from a sound—but dated—basic formula, and have produced an airframe capable of standing up to truly global service. Nevertheless, the design is such that few companies other than Lockheed could build it, owing to the advanced tooling and constructional methods employed.

Fuselage. Although almost the whole usable length is of true circular section, the centres of succeeding frames do not all lie along the same straight line, so that the resulting hull has the Constellation's characteristic dolphin shape. Past "stretching" has complicated the frame-numbering, making it difficult to describe the structure. The origin is ahead of the nose, so that the tip of the radome is at 79.75 (previous aircraft without radar started at 110.2 but all 1649s will have the long nose, although it will be made of metal if search radar is not specified by the customer). The basic numbering ceases at station 527.6 after a clear run of frames spaced 18.4in apart. From this point the mid-section is renumbered from M.0 to M.351.6 (it is divided into forward, centre and aft sections); from the end of the mid-section the original "pre-stretch" numbers run back to the tail from station 658.4 (owing to the Super Constellation stretch the true distance is 879.2in) and the rear pressure-bulkhead is 1,037 (1,257.8 true). In the underside of the fuselage there are a number of intermediate partial frames.

Lack of uniformity is also a characteristic of the floor. From the inward-dished pressure-bulkhead at 150 the floor of the flight deck is level back to station 260; there is then a 10½in step upward, from which point the floor slopes steadily to M.110.4 (just ahead of the leading edge) and then runs level to the convex rear pressure dome. Construction consists of conventional channel frames notched for simple stringers. The strong frames at each end of the centre portion of the mid-section have a true distance from the origin of 669.7 and 774.85. These frames are in line with the front and rear webs of the wing box and each frame meets the box at forged feet which are through-bolted to the wing inboard and outboard (a total of eight bolts), each forged attachment fading out beneath the level of the windows.

Except in the freighters already mentioned, the floor is a conventional structure. The windows have simple pressed frames which, unusually, are frequently allowed to cut into the fuselage frames. The doors are generally of the plug type, being arranged to pull in and slide on rails. The largest door is forward on the port side, measuring 40in × 65in. On the opposite side is a service door and emergency exit 19in × 47.5in. A narrow passenger door is placed aft of the wing to port and a service door and Class-I exit 24in × 48in is farther aft to starboard.

Wing. This is the most interesting part of the 1649 and is a key to the remarkable long-range performance of the aircraft. As already noted the structure is of an exceedingly advanced nature for a slow-speed aircraft in order to provide for high aspect ratio, great internal tankage and, as far as possible, laminar flow. In contrast to the fuselage the geometry is beautifully clear-cut.

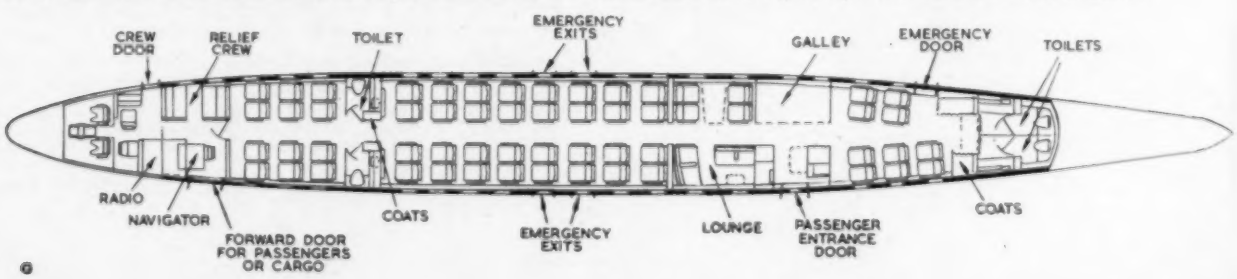
Span is 150ft and dihedral no less than 7½ deg. Each half wing is continuous from the aircraft centre-line to the tip. The basis is a spar running straight and perpendicular to the fore-and-aft axis at 15 per cent chord. From this member to the rear spar, at 63 per cent, the whole wing comprises a vast torsion box, all of which is used for tankage. The ribs are very closely spaced and, except for the massive forged girder ribs carrying the main undercarriage units, are Warren trusses built up from extruded sections. Certain of the ribs are full-depth tank-end ribs pressed from sheet, but the remainder do not run the full depth of the wing but carry small tabs around their periphery which locate on the integral spanwise stiffeners of the machined planks which form the upper and lower skins.

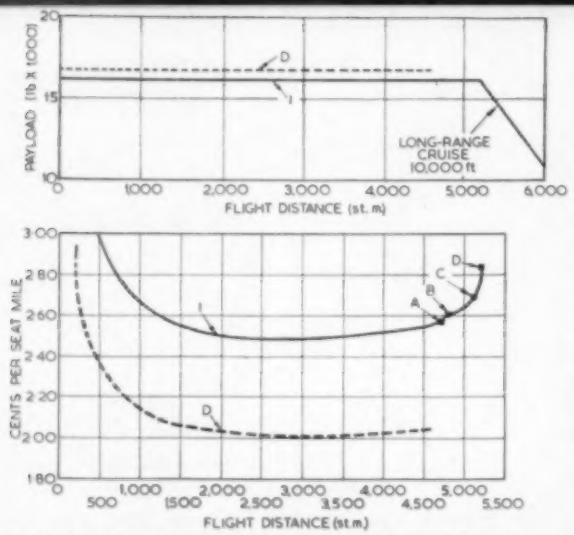
In the 1649 the whole top and bottom of the wing box is formed from the largest machined panels yet built for a transport aircraft. Each plank is machined in an Onsrud spar-mill from a billet of 75ST (bottom panels) or 78S-T6 (top) to form integrally stiffened planks from 22ft to 37ft long. The largest run from the wing tip to the outer engines while the remainder run from the latter point to the centre-line. As the inter-web spread increases towards the root, additional planks are brought in until at the root there are five 24in panels top and bottom, adjacent sections being joined by double rows of rivets. The leading edge sub-structure with its multiple riblets is hinged to fold upwards as far as the outer engines to provide access to interior services. The trailing edge is stabilized by an improved pattern of beaded skin as in the Electra. The inner skin is of 0.02in sheet, joggled 1in deep and bonded on.

Tail. The familiar triple-tail—trade mark of the Constellation—has undergone subtle changes during its history. In the 1649 the chief modification is a slight increase in chord of the horizontal surfaces to reduce the thickness/chord ratio to a value compatible with that of the wing and the span has also been increased. Conventional two-spar structures with lattice ribs are used throughout the empennage, although heavier gauges are used in some portions than are employed on the 1049. The rudders are still fabric covered.

Undercarriage. All three assemblies are basically similar to those of earlier Constellations, although each main leg is a new design of considerably more massive construction to accept the increased weight of the aircraft and to allow each main unit to be used as a speed brake.

The main legs are large forgings with a very wide cross-piece at the top braced to the main leg forging. The gear retracts forwards under the influence of twin jacks (one to each hydraulic system) attached to the bottom boom of the front spar and pushing on horns on the upper cross-member. A nut-cracker drag strut is anchored at an adjacent point on the wing box and is broken by its own jack mechanism. The main leg pivots are outside the wing box and are through-bolted to the large forged girders inside, each of which is roughly 30in deep and 9ft long. Owing to the wide span-wise spread of the cross-piece and the considerable dihedral, the outboard mounting trunnion is considerably deeper than the inboard. Retraction is completed in less than 12 sec with the critical outer engine inoperative. Each unit can be mechanic-





D and I are domestic (16,960 lb payload) and international (16,260 lb) aircraft; A, B, C and D are long-range cruise heights falling from 22,600ft to 10,000ft; 1955 A.T.A. method with 3 hr reserve fuel.

Airliners of the World

L.1649A

ally released for use as a speed brake at indicated speeds up to 233 kt (269 m.p.h.), without power, the leg free-falling and locking over the dead-centre in the down position. The legs carry twin wheels with anti-skid, hydraulic disc brakes.

A legacy from early Constellations is the fact that the nose gear retracts backwards—an unusual feature in modern aircraft and one which Lockheed would no doubt have liked to change. In order to ensure positive lowering, the unit can be extended by either of two actuating cylinders, each served by its own hydraulic system; emergency extension can be affected by an electrically driven, stand-by pump.

Flying Controls. All control surfaces are hydraulically boosted by a new pattern of Eclipse-Pioneer hydraulic booster similar to the units used on the C-130 military transport. The units for all three axes have twin cylinders operated by independent systems; and should either system fail, the remaining power is ample for full control, with final manual stand-by. From the flight deck control movements are transmitted through simple cable systems, and the boosters drive push-pull rods which run in anti-friction bearings and drive the surfaces directly. Feel is retained.

Empennage booster units are hung beneath the tail-plane. The rudder booster has a short linkage to a lever under the torque tube of the centre rudder, forward of which are mounted push-pull tubes, supported on links pivoted behind the tailplane rear spar, through which the drive is taken to the outer rudders. The elevator torque tube is driven directly, and an unusual feature of this surface is the mass balance carried on a long lattice girder, pivoted on the front spar of the tailplane. The aileron boosters are mounted on the back of the wing box at the aircraft centre-line and drive through push-pull rods behind the rear web in each half wing.

There are four large flap sections, the two outer portions having reduced chord (52 instead of 56in) and all having a recessed upper surface to mate with the trailing edge of the upper fixed shroud. Each flap section is of the Fowler type, although the tracks are initially straight so that only one-third of the final angular deflection is obtained during the first 85 per cent of flap travel. At the ends of the tracks the flaps encounter cams which push down the flap-rollers to full deflection during the last 15 per cent of movement. The track, roller and actuator assembly is almost identical with that of the Electra. Dual hydraulic motors are mounted inboard, driving the surfaces through torque tubes and ball-bearing screw-jacks, two of which drive each section of flap. At two points the flaps penetrate the wing box and castings are used to seal the tankage where this occurs.

POWERPLANT. The engines are of the new EA series of Wright Turbo-Compound rated at 3,400 h.p. for take-off. In the 1649's EA-2 engine the reduction gear ratio has been reduced from 0.4375 to 0.355 and the airscrews have been increased from 15ft 2in to 16ft 10in diameter, the largest used on any transport. The slow rotational speed will reduce exterior noise level and this is further improved by the clearance of 62.6in between the inboard airscrews and the fuselage (more than four times as great as on the 1049). Each airscrew has only three blades, as in all previous Constellations, and two makes are available; T.W.A., for example, have specified Hamilton Standard with forged light-alloy blades, and Air France are remaining faithful to Curtiss with hollow steel blades.

The nacelle structures are built up from multiple rings and incorporate boxes for the retracted main landing gear which leave the main integral wing structure undisturbed. Engine and airscrew loads are taken back through conventional tubular mountings to the firewall, from which point the loads are dispersed within the stress-bearing nacelle by heavy channels which fade out into the nacelle structure. A large saddle oil tank is mounted in each nacelle, the inboard tanks being of a curious L-form with a long axial portion and a branch running down behind the firewall; the inner face of each inner tank is moulded to fit the retracted main wheels and large, full-flow filters are incorporated.

The double-skin petal cowling consists of a bottom portion hinged at the rear and a central upper beam, also hinged at the rear and to which are attached the two large side panels which hinge outwards. Carburetter air is drawn in through a flush intake beneath the upper beam and ducted between the outer and inner skins. Oil coolers are mounted in separate air trunks beneath the lower portion of cowling.

SYSTEMS. Air-Conditioning. It is in this system, more than any other, that the 1649 shows the greatest departure from previous Constellation practice. Most of the basic equipment is packaged into identical port and starboard assemblies in each outer nacelle, comprising two heat exchangers, an air-cycle unit and mixing valve, supplemented by a combustion heater in each wing fillet. Intakes to the two cabin blowers and primary heat exchangers are in the wing leading edge, and the secondary heat exchangers draw air from intakes on the wing under-surface.

Pressure air to the cabin is ducted inboard behind the wing box, passing through a water separator on the way, and enters the fuselage near each heater. It is then divided into different types of conditioned air, the major proportion being taken up through risers around both sides of the centre fuselage to a three-section roof duct. Extraction is at foot level, and pressure relief and inwards relief valves are mounted on the rear pressure-bulkhead. Flight-deck air is supplied by a separate system, with an auxiliary fan and heater.

Fuel. Every possible drop of fuel has been accommodated by making the entire wing-box, from tip to tip, into an integral tank. Reading from starboard to port the bays are numbered 1, 2, 5, 7, 6, 3 and 4. Between 2 and 5 to starboard and between 6 and 3 to port are dry bays behind the inboard engines. Tank 7 is a capacious box beneath the cabin floor, filled from the port wing root via a large riser branch which pierces the root ribs.

Provision is made for pressure- and gravity-fuelling and for emergency fuel-jettison. All booster pumps are mounted at the rear inboard ends of the tanks, feeding through lines contained wholly within the tanks as far as the front of the wing-box in line with each engine.

Hydraulics. In conformity with Lockheed's strong leanings towards fail-safe design there are two completely independent hydraulic systems, each operating at 3,000 lb/sq in. A multi-plunger Vickers pump is carried on each engine, the pumps being tied in pairs to feed the dual systems. Services supplied include the undercarriage, flaps, wheel brakes, control boosters and nosewheel steering.

Electrics. A D.C. system is employed, supplied by six 375-amp generators feeding a stabilized line voltage of 30. Advanced protection and feeder-fault systems are incorporated and all cables are nylon-covered and resistant to synthetic oils and low-temperature, fire-resistant hydraulic fluids.

Ice-Protection. Originally Lockheed considered the use of hot-air de-icing for the main plane but concluded that, owing to the thin wing-section and the very great span, it would be preferable to adhere to the pneumatic-boot method used in previous Constellations. Each leading-edge structure can be unscrewed from the front of the wing box, and the profile is recessed so that the uninflated boots do not mar the exterior shape of the aerofoil. Goodrich high-pressure boots are used, cemented direct to the outer metal skin.

A similar method of protection is employed on all leading edges of the tail. The airscrews are de-iced by alcohol slingers fed from tanks in the outer nacelles, and Nesa windscreens and electric blankets on the h.f. aerial mast complete the protection.

FLIGHT EQUIPMENT. Curiously, although the flight deck is fully equipped for an operating crew of four, there is a navigator's station farther aft, completely isolated from the rest of the crew by a bulkhead. To starboard in this rear compartment is a crew-rest area. The seating for the radio officer and engineer is shown in the main drawing. In practice the extreme duration of possible 1649 schedules may require operation with two complete crews on board.

Search radar is available, and all 1649s have the same nose profile irrespective of whether or not such equipment is fitted. An autopilot is standard and is coupled hydraulically to the flying-control boosters.

PAYLOAD ACCOMMODATION. Owing to its long-range nature it is probable that most 1649s will be equipped to carry not more than 62 passengers in four-abreast seats of a new pattern.

Although the payload is space-limited at the moderate level of 17,000 lb this can be carried for a still-air distance of 5,300 st.m.; standard seating is from 58 to 64, although up to 93 tourist seats can be installed if necessary. All passenger seats are stressed to 9g and are mounted on rails. Total floor area of the passenger cabin is 744 sq ft. The aggregate capacity of the two underfloor freight holds is 540 cu ft; access is provided through doors on the under-side of the fuselage 30in x 40in and via 16in x 19.25in hatches in the floor.

COMMERCIAL HISTORY. Early history has already been described and the following are present operators of "un-stretched" Constellations: L.049, Capital 12 (in process of selling these), Cubana 2, El Al 4 and T.W.A. 32; L.649/749, Aerovias Guest 2, Air France 20, Air-India International 3, B.O.A.C. 16, Eastern 19 (of which many have considerably exceeded 30,000 hr), K.L.M. 10, L.A.V. 2, South African 4, and T.W.A. 39.

Operators, or future operators, of 1049 Super Constellations are: L.1049, Eastern 14 and T.W.A. 10; L.1049C, Air France 9, Air-India International 2, Avianca 3, Cubana 1, Eastern 16, Iberia 3, K.L.M. 12, Pakistan International 3, Qantas 10, T.C.A. 7; L.1049D, Seaboard and Western 4; L.1049E, Air-India 3, L.A.V. 2 and T.W.A. 10; L.1049G, Air France 14, Air-India 3, Cubana 2, Eastern 10, Iberia 2, K.L.M. 4, L.A.V. 1, Lufthansa 8, Northwest 6, Qantas 2, Thai Airways 2, T.A.P. 3, T.C.A. 2, T.W.A. 28, and Varig 3; L.1049H, California Eastern 3, Flying Tiger Line 10, Qantas 2, Seaboard and Western 5, Slick 5 and U.S. Overseas 2.

The first L.1649A is due to fly in October and certificated machines are to follow next spring. The first machines are now taking shape, and the wing and fuselage of the first were mated last month. Orders already placed are: Air France 10, Lufthansa 4, L.A.I. 4, T.W.A. 25 and Varig 2. All these orders are to be fulfilled from 1957, except for Lufthansa who get their first 1649 in 1958. The price of each, with spares, is about £1.25m.

This is the low pressure stator blading of the Bristol BE 25 supercharged turboprop engine. It is part of an "inside story" which has made the BE 25 a power unit of unique importance to the commercial aircraft of the future, for this Bristol engine is unique in possessing the ability to maintain a constant power of 4000 hp from sea level to heights around 20,000 feet.

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Because of this solid safety margin, the Eland has a more flexible operational range than any other turbo-prop. It is the most economical answer to many of the most urgent problems of air transport.

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They give the Eland the same ease of handling, the same kind of acceleration, that you get from a piston-engine. Low idling speeds offer considerable savings of fuel during tarmac-waiting and taxi-ing and a correspondingly lower noise level in the cabin. The noise level is much lower outside, too—an important consideration in these days of noise abatement.

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The first such system based on principles of proven reliability. The first such system whose tuning is readily checked.

IS BEGINNING ...

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First control system that automatically compensates for ambient pressure, temperature, altitude and forward speed

The Eland is the first turbo-prop that can be guaranteed to work at maximum efficiency under every operational condition.

First engine control working from a fundamental parameter of the turbine inlet temperature

The Eland is the first turbo-prop in which the fuel is metered precisely and automatically to the predetermined needs of the turbine. This control, safeguarded by a patented mercury-vapour boiler, is typical of the built-in safety and economy of the Eland.

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An original design technique has produced a built-in hydraulic torquemeter that has uniform automatic loading. This is of immense practical importance for it means that every Eland flight can be scheduled for maximum economy and range.

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Napier's particular design technique has produced a lightweight gear which is entirely free from vibration, has no whine, and substantially lowers cabin noise.

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This new system, developed in collaboration with Lucas, has fundamentally increased the safety of the turbo-prop engine. It enables the Eland to work over a uniquely wide range of air/fuel ratios. The Eland can be throttled back, keeping the r.p.m. up, without the flame going out. This makes possible sudden and safe bursts of acceleration that may be vital in dirty-weather flying or for service aircraft.

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Airliners of the World

HERALD

HANDLEY PAGE, LTD., CRICKLEWOOD, LONDON

IN the early years of the present decade Handley Page conducted an intensive survey of local-service and short-haul operators in all parts of the world in an earnest endeavour to formulate some sort of conclusions regarding the type of aircraft necessary to replace their fast-wearing-out equipment. It is exceedingly difficult to carry such a task to completion in the face of such variables as: low- or high-mounted wing; piston engines or turboprops; and two engines or four. Gradually, however, the H.P.R.3 project took shape and in 1952 detailed design began along the lines which are now familiar.

As befits a company with the traditions and integrity of Handley Page, very extensive testing and development paralleled the construction of the prototype, although the latter task took only 15 months. New techniques, including advanced spot-welding and sandwich construction, are embodied in the airframe. These have been extensively proved in the company's military work. The Herald has now emerged as an aircraft carefully engineered to meet the general needs of a large number of operators in virtually every country.

AIRFRAME. The wing consists of a centre section, two outer panels, and the tips. The form of the structure is clearly shown in the cut-away drawing, which reveals such curious features as the corrugated-sandwich web and upper and lower booms in the spar, which extends only across the centre section. Over this portion of the wing the skin also is a metal sandwich formed from a corrugated filler spot-welded to inner and outer skins. The outer panels revert to a more conventional form of construction. One of the advantages of the sandwich skins in the centre section is that ribs are required only at the attachment points of the undercarriage, nacelle, outer panels and fuselage.

The fuselage has a section formed from various circular arcs, the two principal radii intersecting on two chine beams running longitudinally at the sides of the wide floor. The multiple frames are Z-sections above the floor and pressings below; to them are pop-riveted the top-hat stringers to which the skin panels are spot-welded. The fuselage is pressurized and the main frames aligned with the front and rear wing webs are box-sections stressed to withstand belly-landing loads. The main doors are to port with emergency exits on the opposite side.

Regarding the tail construction, little needs to be added to supplement the drawing. The use of fluted skin makes possible a very simple internal structure and it has been widely employed. The undercarriage is a product of Electro-Hydraulics and comprises single shock-struts carrying twin wheels, each unit retracting forwards hydraulically into a bay sealed by twin doors, closed by mechanical links to the leg. The main units are each hinged from a forging attached to the rear web and *ad hoc* ribs in the centre-plane, and the wheels, tyres (inflated to the low pressure of 50 lb/sq in) and hydraulic disc brakes are supplied by Goodyear. The nosewheels can be steered hydraulically by a wheel on the control column through ±55 deg.

Flying controls are all manual. The elevators and rudder each carry a sloping horn balance and are aerodynamically balanced by geared tabs and mass balances along the leading-edge beaks. Geared tabs are fitted, of which one on each surface can be used for trimming. The ailerons are similar in the use of tabs and internal balance but horn balances are not fitted. A single large Fowler-type flap is fitted on each wing, running in four guide rails and lowered by hydraulic rams, cables and chains.

POWERPLANT. The standard engine is the Alvis Leonides Major 14-cylinder, two-row, piston engine rated for take-off at 850 h.p. It is expected that, when the Herald becomes ready for service next year, the overhaul period will be at least 400 hr, and probably 600 hr.

The airscrews are by de Havilland Propellers with three blades fitted for feathering and optional reversing, the diameter being 11ft. Petal-type cowlings, as shown in the drawing, provide excellent accessibility. Intakes for the oil cooler and engine air are integral with the upper and lower petals; the exhaust is discharged on the outboard side of each nacelle and accessories are mounted behind the firewalls.

SYSTEMS. Air Conditioning. The design pressure differential is 3.35 lb/sq in. Ram air enters through an intake in the leading edge between each pair of engines and passes through Vokes filters to two Godfrey blowers, one of which is driven by each outboard engine. The air is then passed through heat exchangers in the nacelles, where it is cooled by ram air, and is then ducted behind the main wing box to the ceiling panels of the passenger cabin which it enters at foot level and through individual louvres. The air is extracted between the interior trim and fuselage skin and leaves beneath the floor. In a fully furnished and part-insulated Herald, the cabin temperature can be stabilized at 18 ±3 deg C above 10,000ft with an o.a.t. from −30 deg C to inter-continental maximum.

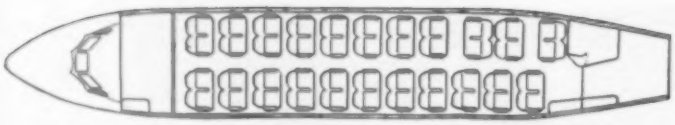
Fuel. The system has been designed to satisfy both the A.R.B. and C.A.A. There are four flexible tanks which each hold 175 gal between the inner and outer engines and on each side of the fuselage, giving a total of 700 gal. At the root of each outer panel an auxiliary 75-gal tank can be fitted.

Hydraulics. Pumps are mounted on the port inner and starboard outer engines, energizing the system to 3,000 lb/sq in. Hydraulically operated services include the undercarriage, flaps, nosewheel-steering and brakes. Emergency services are provided by air bottles connected by independent piping.

Electrics. Each inner engine drives a 6 kW D.C. generator regulated at 28.5V to give a normal rating of 200 amps. These bear the main generating loads at engine speeds above 2,000 r.p.m. Each outer engine drives a 7.5 kVA alternator; the port unit supplies power for ice protection and the starboard alternator acts as a stand-by, and, through a transformer/rectifier unit, provides the D.C. current for taxying, ground-idling and emergency services. Two inverters in the nosewheel bay provide 115-V current at 400 c.p.s. for instruments and radio. The system is currently being somewhat altered.

De-Icing. In each outboard nacelle is a heat exchanger in which fresh ram air is heated by exhaust gas and ducted along the leading edge of the wing and, between the ceiling trim and top of the fuselage, to the tail unit where the duct divides into three to feed the tailplane and fin. At each leading edge the skin is stiffened by a spot-welded inner skin with corrugations which leave chordwise passages approximately 0.1in deep for the hot air. If icing is not expected to be severe mechanical overshoes can be fitted as an alternative. The airscrews can be electrically de-iced and the pilot's windscreen may have either an electric or fluid system.

FLIGHT EQUIPMENT. In most normal operations the Herald will have a crew of two, although a station for a radio officer can be provided. For ferrying purposes the aircraft can quite easily be flown solo. Radio controls are in the roof and further services are controlled from consoles at the sides of the cockpit, that to port embodying the



Standard 44-seat layout.

Airliners of the World

HERALD

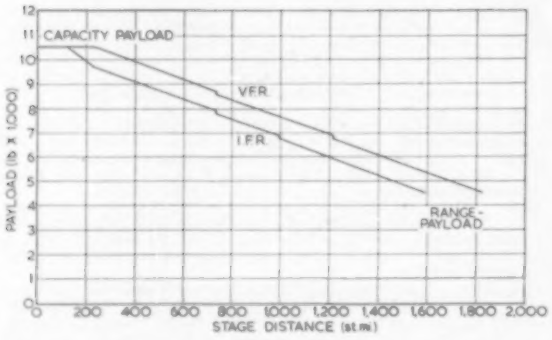
pressurization controls. Navigation and communication equipment suitable for the Herald includes: STR. 12D V.H.F.; STR. 18C H.F.; AD. 107A/114 H.F.; Ultra intercom.; AD. 7092D A.D.F.; STR. 30 radio altimeter; D.M.E.; I.L.S.; and Sperry Zero Reader.

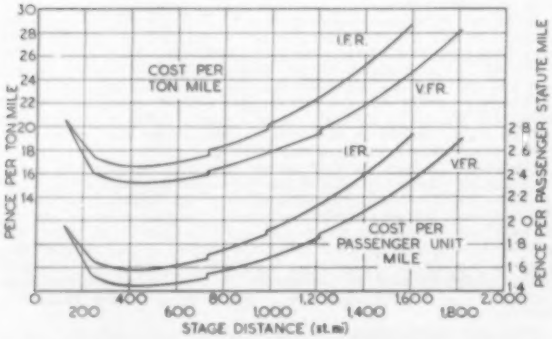
PAYLOAD ACCOMMODATION. The unobstructed cabin can provide seating for at least 44 (as shown in the floor plan), floor area being 220 sq. ft. In this arrangement the movable bulkheads are positioned to give 90.5 cu ft of space between the cabin and the flight deck, the rear freight compartment of 171 cu ft being retained in all passenger versions. When used solely for freight the usable volume, with gangways clear, is 1,575 cu ft.

The main entry door at the rear consists of two hinged panels opening outwards fore and aft, the rear (freight) door being 3ft × 4ft 8in and the forward (passenger) portion being 2ft 6in × 5ft 2in. As an alternative to this arrangement operators can have either a 5ft 6in × 5ft door hinged into upper and lower portions with built-in steps, or a single passenger door with built-in steps and a separate luggage hatch. The forward crew-door is 3ft × 3ft 10in. The door sills are 3ft 6in from the ground.

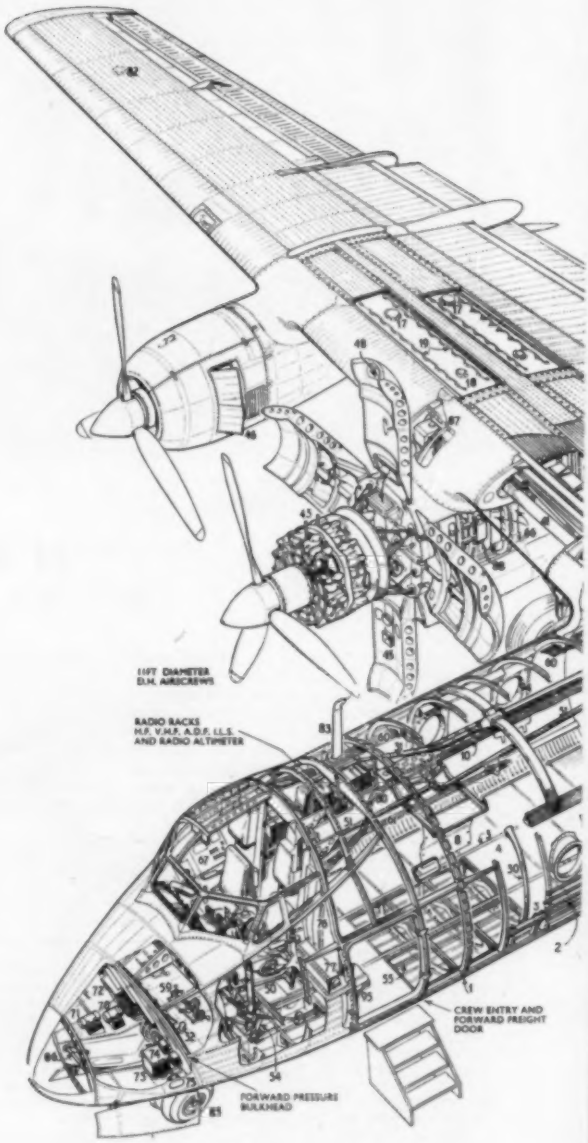
COMMERCIAL HISTORY. The first aircraft built flew on August 25, 1955, and has since completed well over 100 hours. Further aircraft are well advanced and production is in hand for a run of 100. The second machine is almost ready to fly and will be used to prove the cabin pressurization and de-icing systems, and for tropical trials followed by overseas demonstration flights. Structural tests on a complete fuselage are in progress at Radlett and another fuselage is being pressure tested at Woodley, where Herald work is centred.

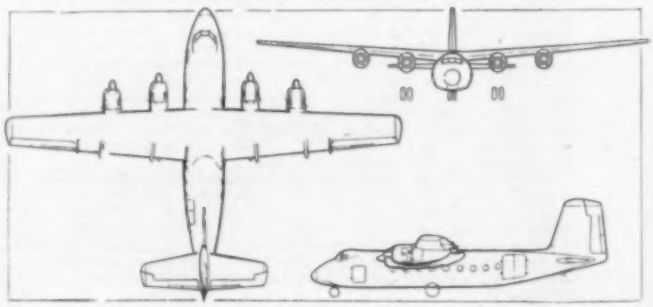
The first order was announced in October 1954, when Queensland Airlines ordered an unspecified number for delivery in 1957. In February 1955 Australian National Airways placed an order for "a large fleet," and the following month Lloyd Aereo Colombiano ordered a batch bringing sales up to 29 by that date. Late September Air Kruise placed a firm order for six. The price of the Herald is in the region of £130,000-£140,000. Handley Page have also prepared developments of the Herald for military service, including a version with clamshell doors under the rear fuselage to allow the carriage and air-dropping of heavy freight.





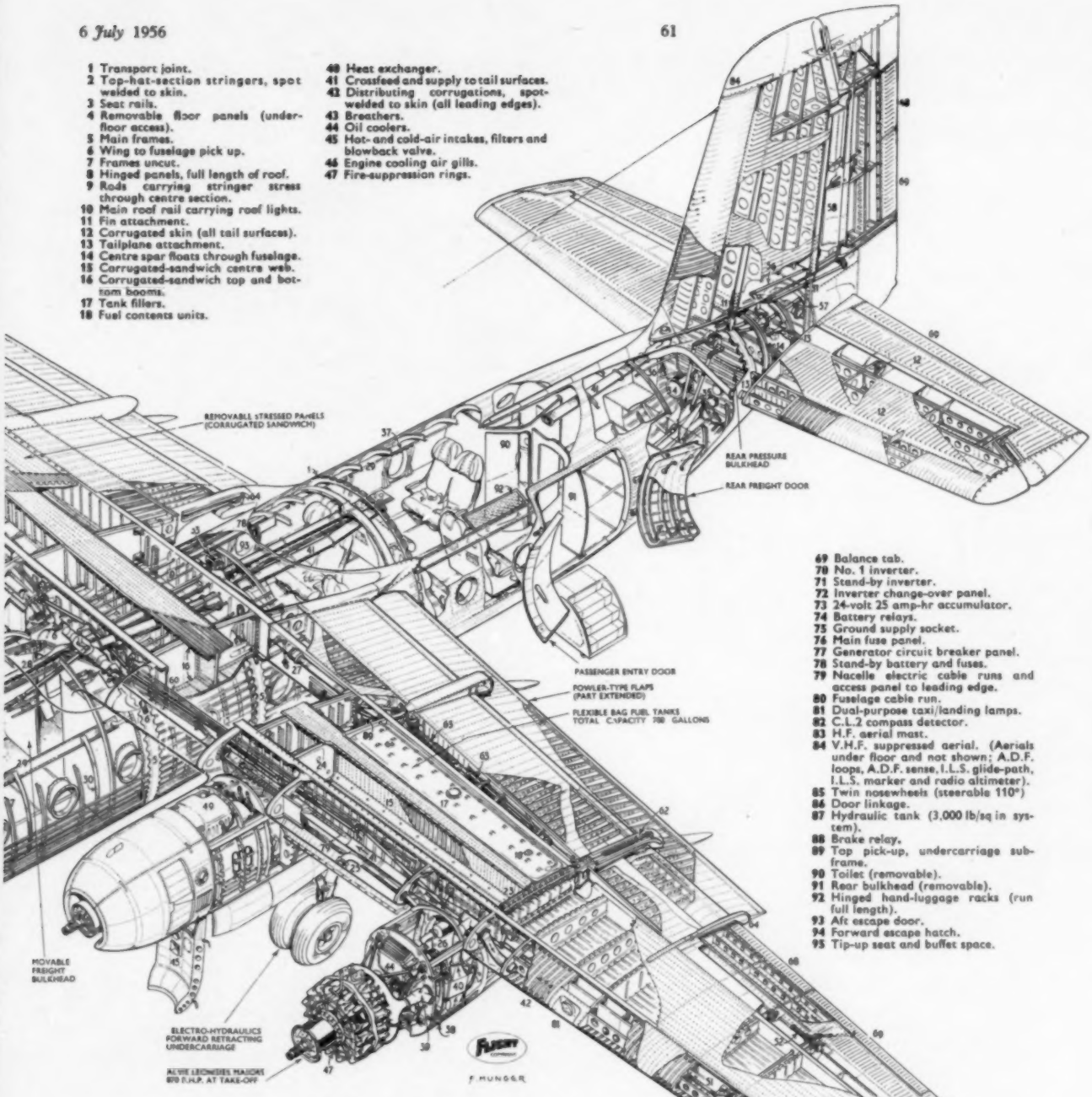
Payload/range and cost curves for a 36-seat Herald cruising at 10,000ft on 50 per cent M.E.T.O. power in still air. Costs assume 3,000 hr utilization on S.B.A.C. method, using 1 passenger unit = 213 lb.


11FT DIAMETER D.H. AIRSCREWS
RADIO RACKS H.F. V.H.F. A.D.F. I.L.S. AND RADIO ALTIMETER
CREW ENTRY AND FORWARD FREIGHT DOOR
FORWARD PRESSURE BULKHEAD



1 Transport joint.
2 Top-hat-section stringers, spot welded to skin.
3 Seat rails.
4 Removable floor panels (under-floor access).
5 Main frames.
6 Wing to fuselage pick up.
7 Frames uncut.
8 Hinged panels, full length of roof.
9 Rods carrying stringer stress through centre section.
10 Main roof rail carrying roof lights.
11 Fin attachment.
12 Corrugated skin (all tail surfaces).
13 Tailplane attachment.
14 Centre spar floats through fuselage.
15 Corrugated-sandwich centre web.
16 Corrugated-sandwich top and bottom booms.
17 Tank fillers.
18 Fuel contents units.

40 Heat exchanger.
41 Crossfeed and supply to tail surfaces.
42 Distributing corrugations, spot-welded to skin (all leading edges).
43 Breathers.
44 Oil coolers.
45 Hot- and cold-air intakes, filters and blowback valve.
46 Engine cooling air gills.
47 Fire-suppression rings.


REMOVABLE STRESSED PANELS (CORRUGATED SANDWICH)
REAR PRESSURE BULKHEAD
REAR FREIGHT DOOR
PASSENGER ENTRY DOOR
FOWLER-TYPE FLAPS (PART EXTENDED)
FLEXIBLE BAG FUEL TANKS TOTAL CAPACITY 700 GALLONS
MOVABLE FREIGHT BULKHEAD
ELECTRO-HYDRAULICS FORWARD RETRACTING UNDERCARRIAGE
ALVIS LEONIDES MAJORS 850 H.P. AT TAKE-OFF
F. HUNGER

69 Balance tab.
70 No. 1 inverter.
71 Stand-by inverter.
72 Inverter change-over panel.
73 24-volt 25 amp-hr accumulator.
74 Battery relays.
75 Ground supply socket.
76 Main fuse panel.
77 Generator circuit breaker panel.
78 Stand-by battery and fuses.
79 Nacelle electric cable runs and access panel to leading edge.
80 Fuselage cable run.
81 Dual-purpose taxi/landing lamps.
82 C.L.2 compass detector.
83 H.F. aerial mast.
84 V.H.F. suppressed aerial. (Aerials under floor and not shown; A.D.F. loops, A.D.F. sense, I.L.S. glide-path, I.L.S. marker and radio altimeter).
85 Twin nosewheels (steerable 110°)
86 Door linkage.
87 Hydraulic tank (3,000 lb/sq in system).
88 Brake relay.
89 Top pick-up, undercarriage sub-frame.
90 Toilet (removable).
91 Rear bulkhead (removable).
92 Hinged hand-luggage racks (run full length).
93 Aft escape door.
94 Forward escape hatch.
95 Tip-up seat and buffet space.

19 Cords lacing flexible tanks to top panels.
20 Z-section outer wing stringers.
21 Removable tips.
22 De-icing air outlets.
23 Outer wing joint.
24 Undercarriage.
25 Intake to cabin supercharger.
26 Supercharger and silencer (air *via* spill valve and heat exchanger to cabin).
27 Non-return valve in duct from nacelle to cabin.
28 Main roof duct.
29 Cabin distribution duct.
30 Air piped to floor level duct.
31 Air to cockpit and windscreen de-misting.
32 Cockpit air louvres.
33 Mass-flow control.
34 Main discharge valve.
35 Inwards relief and safety valves.
36 Pipe from pressure controller in cockpit.
37 Individual punkah louvres.
38 Intake to heat exchanger.
39 Control valve, exhaust to heat exchanger.

48 Oil cooler air duct.
49 Oil tank (all nacelles, total cap. 40 gal).
50 Aileron torque rod from column cross-shaft.
51 Aileron push-pull rods.
52 Aileron spring tab torsion bar.
53 Aileron mass balance.
54 Rudder and elevator levers.
55 Rudder and elevator tension rods (under floor).
56 Rudder push-pull rods.
57 Elevator push-pull rod.
58 Rudder sealed balance.
59 Rudder pedals with toe brakes.
60 Pitch and power push-pull rods.
61 Trim and control-lock cables.
62 Flap lowering chain.
63 Flap ram.
64 Flap guide rails.
65 Flap operating cables.
66 Flap and undercarriage emergency lowering air bottle (3,000 lb/sq in)
67 Starboard console, mainly electrics. (Port console removed, autopilot, lights, and Gyrosyn compass controls).
68 Trim tab.

HANDLEY PAGE HERALD

(Four Alvis Leonides Major A.L.e.M. 1-1 of 850 h.p. each)

Dimensions: Span, 95ft; length, 70ft 3in; height, 22ft 6in; wing area, 882sq ft.; flaps, 81 sq ft each side; ailerons, 29.7 sq ft each; tailplane, 202 sq ft; elevator, 61.3 sq ft; fin and rudder together, 199 sq ft; track, 22ft; wheelbase (on axles), 24ft 3in.

Weights: Basic operating weight, 21,136 lb; max. payload, 10,705 lb; zero-fuel weight, 32,380 lb; max. weight (also max. landing weight), 34,000 lb.

Performance: Take-off (see p. 10), 1,410ft run, 1,728ft to 50ft, 2,652ft accelerate-stop; initial climb, clean, 1,820ft/min; time to 10,000ft, 7.7 min; cruise at 50 per cent METO power at 15,000ft, 357 st. m. at 199 m.p.h. with max. payload, or 1,452 st. m. with payload of 6,929 lb; speed at 32,000 lb on max. cont. power 255 m.p.h. at 8,300ft; landing at 34,000 lb (i.s.a.), approach at $1.3V_S$, 104 m.p.h.: ground run, 1,446ft.

Airliners of the World

H.D. 321

SOCIÉTÉ DE CONSTRUCTION DES HUREL-DUBOIS, MEUDON

IN the H.D.321, the Wright-engined higher-powered development of the H.D.32, the Hurel-Dubois company of France have moved a step further in the evolution of perhaps the most aerodynamically original transport aeroplane yet built. Its designers have conclusively shown the world the startling advantages offered by correctly applied high aspect-ratio. Their philosophy is that payload can be doubled for a given power and speed by the use of a suitably designed high aspect-ratio wing and associated bracing struts. In addition, as the performance figures show, take-off and climb are remarkable for an aircraft of the H.D.321's power and weight.

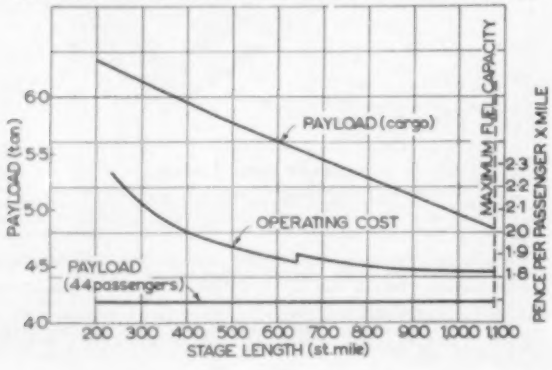
The words "suitably designed" are significant. The Hurel-Dubois formula has been the subject of immense research and a brief discussion of it is appropriate.

The objections to high aspect-ratio are that aerodynamic efficiency falls off as it is increased, and that weight goes up to the power of about 1.5. The latter can be avoided by struts, but drag tends to cancel out any advantages. Other generally accepted objections are that the aircraft is more difficult to fly; that a high aspect-ratio wing suffers from torsion troubles; that c.g. travel is limited; and that leading edge de-icing presents problems.

Hurel-Dubois claim to have overcome all these objections. Their struts are specially designed to overcome induced drag due to interaction of wing and strut (which virtually form a biplane), and the increased profile drag due to interference. By twisting the strut appreciable lift is generated in conditions where minimum induced drag is required; by making it as thin as possible and making its incidence follow the line of the flow, parasite and interference drag are reduced to a very low order. Thus, without excessive increase in weight, a lift-drag ratio of about 40 is achieved, this figure being exceeded by the use of high-lift Fowler flaps during take-off and landing.

Thus the first of the objections raised above is answered. So far as handling and manoeuvrability are concerned flight-tests have shown rate of roll to be satisfactory in every configuration (it exceeds 12 deg/sec at low speeds). The centre of gravity margin exceeds 25 per cent of the reference chord, i.e. 2ft, a limit acceptable on a conventional aircraft of similar weight. Torsional rigidity and flutter have been shown to present no problems; there is no danger of aileron reversal at any speed, and flight test diving speeds of 222 kt have been reached (215 kt is required by regulations). Calculated flutter speed at cruising height is 350 kt I.A.S. The de-icing system, supplied by combustion heaters, bleeds hot air into the leading edges of the wings and struts and has been shown to work completely satisfactorily.

Curves for H.D.321 with Wright 982 (R-1820) engines. Payload/range assumes 230 st. miles alternate +15 min +five per cent; costs assume 8-yr depreciation at 1,500 hr utilization, S.B.A.C. method on I.F.R.



The structure and systems of the H.D.321 conform closely to those of the H.D.32 (described in *Flight*, June 18, 1954) and are straightforward and conventional. The basic difference between the two aircraft is the powerplant, two Wright 982 C9 HE-1 engines of 1,525 h.p. replacing the 1,200 h.p. Pratt and Whitney R-1830-92 engines. Airscrews of the H.D.321, like those of its predecessor, are by Hamilton Standard. The increase in power necessitated an increase in tail volume, achieved by more fin and the addition of auxiliary fins on the tailplane. In addition, capacity of the leading edge de-icing combustion heaters has been increased.

Payload Accommodation. Three versions are offered: a 44-passenger layout; a mixed cargo-passenger version with seating for 34 and 346 cu ft of cargo space in place of five double chairs at the rear of the cabin; and an all-cargo version of 1,441 cu ft (including gangway provision). In each version flight crew accommodation for three is unaffected. A good point in the two passenger versions is that the portion of cabin in line with the airscrews is devoted to baggage space (106 cu ft).

Hurel-Dubois offer the aircraft in other commercial roles also, and have prepared schemes for a photographic survey version and an ambulance version.

Commercial History. The Hurel-Dubois high-aspect-ratio theories were first tested in 1949 when the H.D.10, a small single-seat research monoplane of 39ft 4in span, was built and flown. As a result of its success, the French Government ordered two H.D.31s, a twin-engined transport, the first of which flew in January 1953, powered by two 800 h.p. Wright engines. The higher-powered H.D.32 followed later in the year. This aircraft was not produced in numbers, although it was rumoured that Air France had ordered 24; production of the H.D.321 is, however, progressing well and first deliveries will be to the Institut Géographique Internationale beginning next February. The Institut has ordered an undisclosed number of the type 34, which is the photographic version of the 321 having a slightly longer front fuselage to accommodate a photographer in the extreme nose.

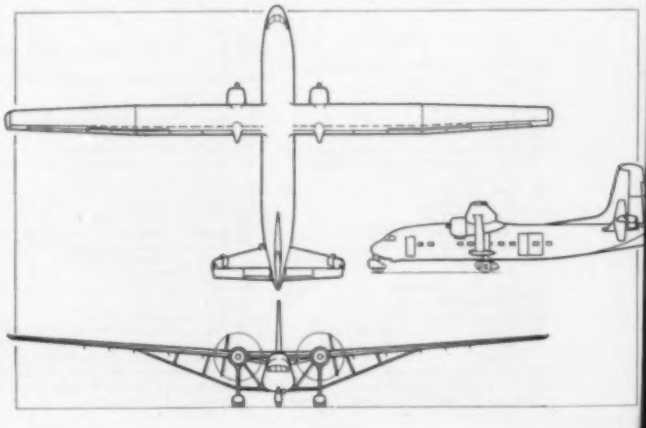
H.D.321

Two Wright 982 C9 HE-1 of 1,525 h.p.

Dimensions: Span, 148ft 7.5in; length, 76ft 4.3in excluding nose-wheel spat; height, 27ft 6.7in; gross wing area, 1,076.43 sq ft (aspect ratio 20.2); track, 23ft.

Weights: Empty, 22,758 lb; operating weight as freighter, 25,463 lb; maximum take-off, zero-fuel and landing weights, all 41,225 lb.

Performance: Take-off to 50ft, 2,460ft; second-segment climb, one feathered, 254ft/min; climb at 5,000ft, 855/ft min; cruise at 39,600 lb at 9,850ft on 690 b.h.p. per engine, 166 m.p.h.; landing from 50ft, 1,900ft (3,170ft required field length).



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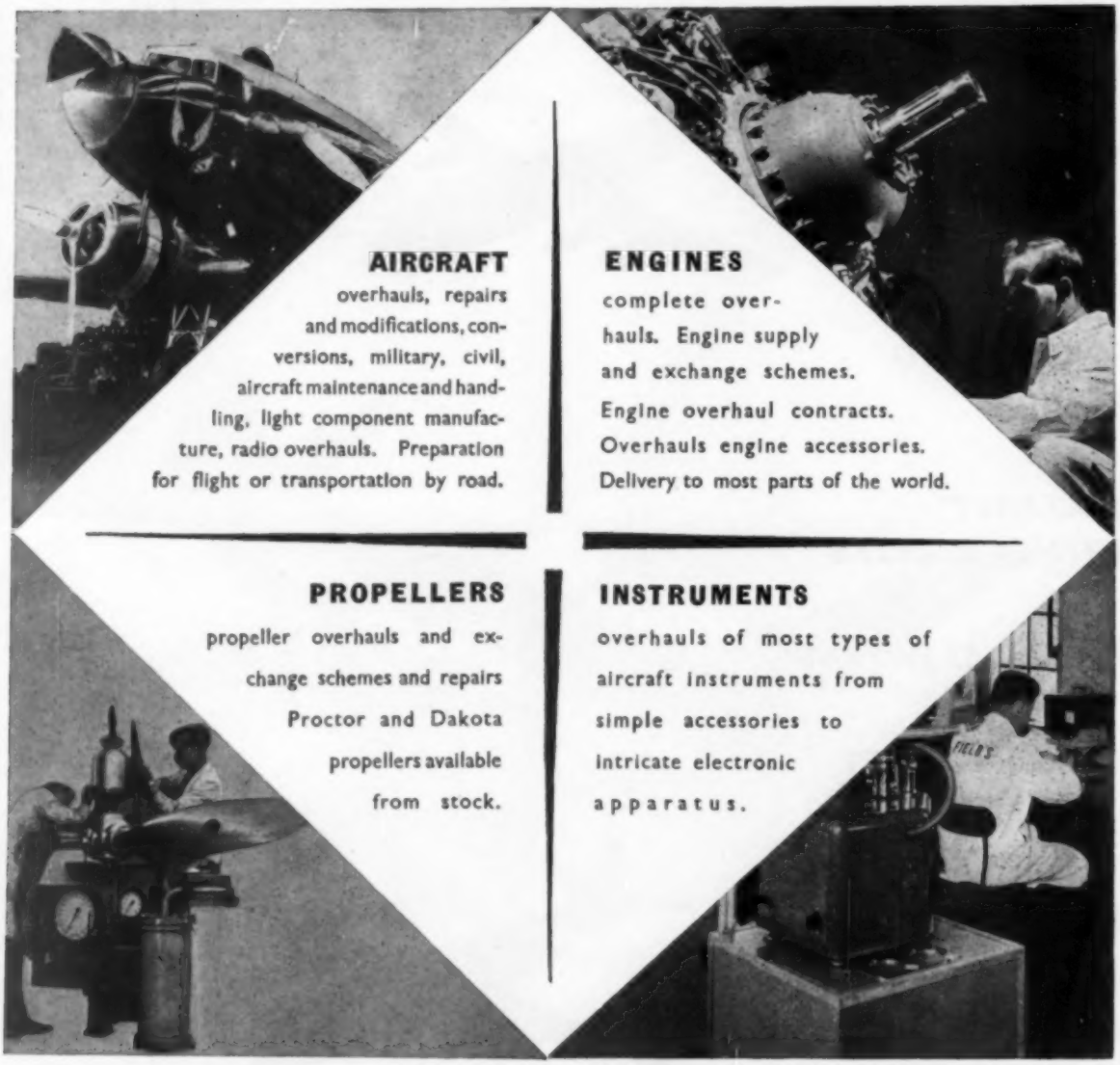

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Airliners of the World

TWIN PIONEER

SCOTTISH AVIATION, LTD., PRESTWICK AIRPORT, AYRSHIRE

FIRST commercial aircraft to be designed in Scotland, the Twin Pioneer is a larger, twin-engined development of a multi-purpose type widely used for short-field or jungle operations by the Royal Air Force. Scottish Aviation, Ltd., sum up the Twin Pioneer's *raison d'être* as follows:—

"The basic design philosophy of the Pioneer series of aircraft was to produce aircraft capable of using unprepared surfaces in restricted spaces, thereby providing the means of extension of services to those areas in which it would be either uneconomical to provide the necessary runways for the operation of aircraft with higher take-off and landing speeds such as are in general use today, or where geographical conditions were such that normal length runway strips are just not possible. In addition it was felt that such an aircraft had many potential uses in the military field in the transport of troops and equipment into areas remote from points where such troops and equipment would be landed on main airfields by the larger long-range military transports. It was also evident that this type of aircraft, capable of using smaller airfields closer in to city centres, could, despite its relatively low cruising speed, considerably reduce the city-centre-to-centre times of inter-city services."

Airframe. The whole airframe is very simply built up from standard sheet and strip, mainly of 20, 22, or thinner gauge, using mushroom-head rivets. The wing comprises a centre section and two outer panels, all three sections having two spars and closely pitched pressed-sheet ribs. Each outer panel is braced by an extruded, streamline-section strut, and carries powered slats which open when the flaps are depressed to 12 deg or more. There are four Fowler-type flap portions, running out to a maximum of 30 deg by a double-acting hydraulic ram, torque-tubes and chain drives.

Of basically square section, the fuselage is built in front and rear portions joined at station 158. The multiple-channel half-frames are butt-jointed together along the upper centre line and the keel member; those at stations 185.5 and 249.6 are heavy frames in line with the wing spars. The tail is a conventional all-metal assembly, with interchangeable outer vertical surfaces. The ailerons are fabric covered, all controls being manual. Electro-Hydraulics supply the three undercarriage units, the main gear having twin wheels on each leg with Dunlop three-cylinder, single-plate hydraulic brakes.

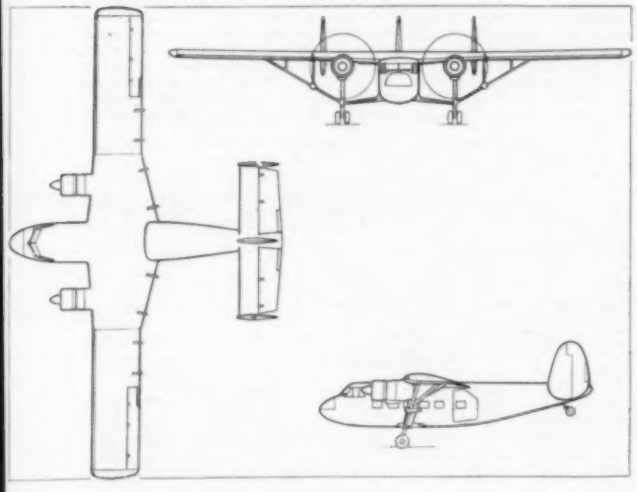
Powerplant. Each engine is an Alvis Leonides 503/8 nine-cylinder radial, rated at 540 h.p. They are geared (0.5 : 1) to 11ft three-blade de Havilland constant-speed airscrews and are installed as complete engine-change units, interchangeable port and starboard. Starting can be by electric motor (which can also act as the feathering pump) or cartridge, and methyl bromide bottles are mounted in both of the two bays in each nacelle. Behind each firewall is a 7-gal magnesium oil tank.

Systems. Each engine drives a Newton 1.5 kW D.C. generator which serves a 28-volt system. Electrical equipment includes starter (optional), tank booster pumps, feathering pumps, and the pump driving the hydraulic system of the Dunlop wipers. Each engine also drives a Lockheed Mk 7 hydraulic pump which energizes a 2,500 lb/sq in system driving the slats and flaps and also charging an emergency air bottle.

Standard tankage comprises four Fireproof Tanks bags between the wing spars, two housing 55 gal and two 30 gal apiece. This total of 170 gal can be increased by the addition of a 30-gal tank in each outer wing. Interior cabin heating is provided by a new pattern of Delaney Gallay exhaust heat-exchanger, and de-icing (an optional extra) is of the T.K.S. fluid type.

Payload Accommodation. The interior is quite unobstructed by any structural members. The main door is 62 × 47in and an emergency door is provided on the opposite (starboard) side, supplemented by a third emergency hatch in the roof, forward. Interior measurements, aft of the cockpit bulkhead, are 19ft long and 5ft 8in high. The standard passenger accommodation is for 16 in lightweight seats: five to port and one single and five double seats to starboard. As an ambulance the Twin Pioneer can carry nine stretcher cases, two walking casualties and two attendants, and corresponding loads can be worked out for other specialized rôles. Projects exist for floatplane versions and for a true freighter, capable of fulfilling important military and commercial requirements, with large clamshell doors at the rear.

Commercial History. The first prototype has now been flying since June 1955 and has logged some 300 hours. On April 24th of this year a second machine (illustrated in the heading picture) flew and other aircraft are approaching completion. All have been built in production jigs and preparations are in hand for a run of 200 aircraft. The type has attracted substantial interest in all parts of the world, and quantity deliveries are virtually assured.



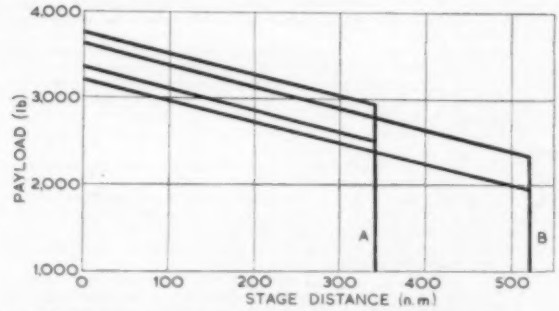
TWIN PIONEER

Two 540 h.p. Alvis Leonides 503/8

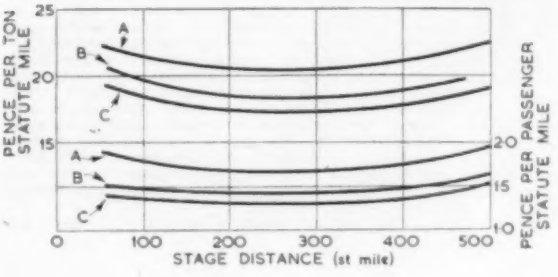
Dimensions: Span, 76ft 6in; length, 45ft 3in; height, 13ft 8in; wing area, 657 sq ft; vertical tail area, 166 sq ft; horizontal tail area, 161 sq ft.

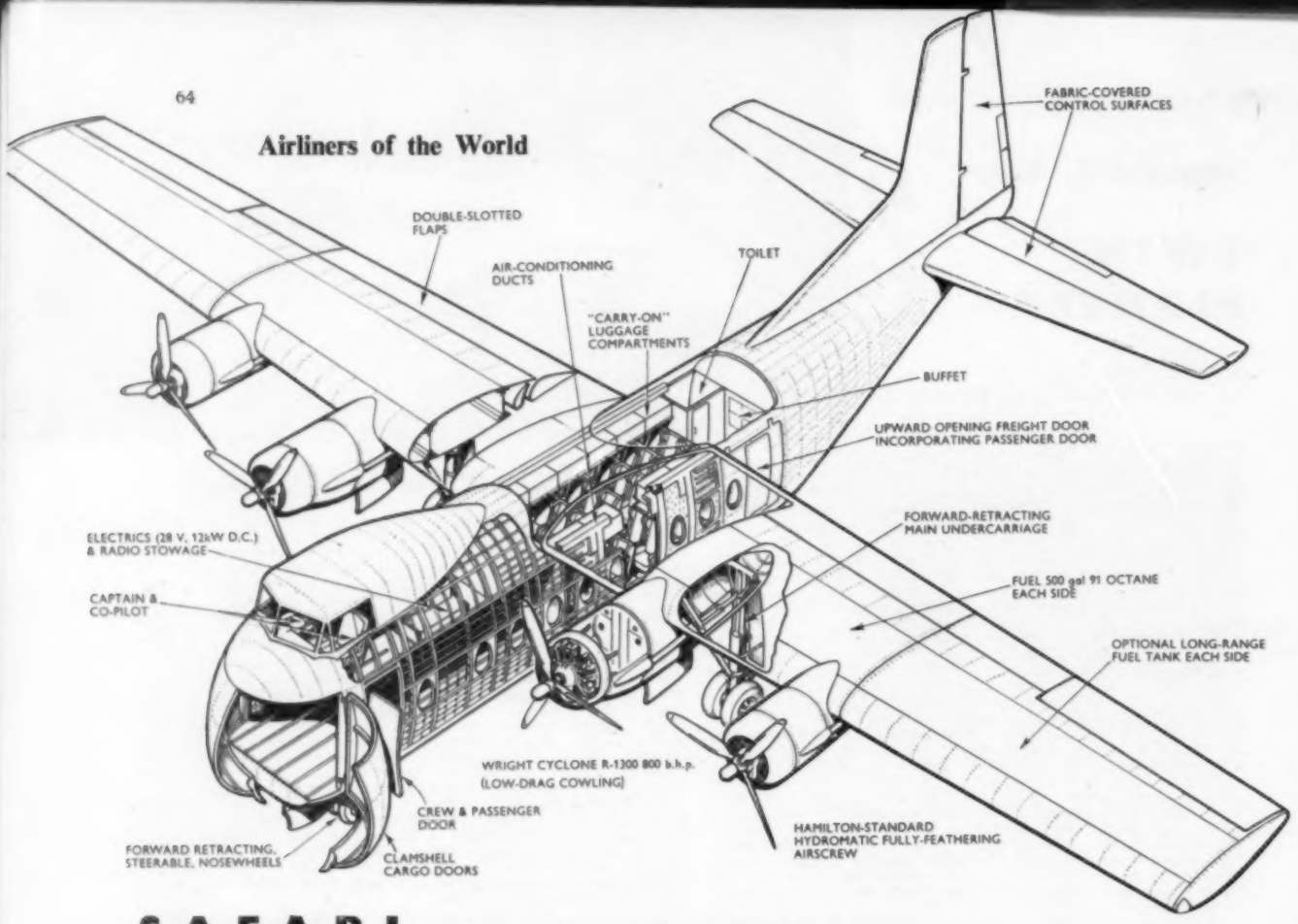
Weights: Empty, 8,936 lb; 16-passenger, furnished, 9,376 lb; operating weight, 10,921 lb; max. weight, 13,500 lb.

Performance: Take-off (see p. 10), minimum unstick distance, 312-380ft; to 50ft, 1,128-1,170ft; landing, 1,101ft from 50ft with 420ft ground run; w.m. cruise, 141 m.p.h., or 107 m.p.h. for 3.55 a.m./gal.



Payload/range and cost assumptions: cruise at 40 per cent power, i.s.a. at 13,500 lb, still air at 5,000ft; 100 n.m. diversion+15 min+ five per cent; S.B.A.C. costs, with A, B and C being annual utilizations of 1,000, 2,000 and 3,000 hours. Payload: upper curves, freighter, lower curves are for 16 seater with toilet; A=170 gal, B=230 gal.

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SAFARI

THE FRYE CORPN., FORT WORTH, TEXAS

THE design philosophy of the Frye F-1 Safari has been described for this issue of *Flight* by the man whose inspiration it is—Mr. Jack Frye, president of the Texas aircraft corporation which bears his name.

"The F-1 Safari," writes Jack Frye, "is based on the belief that the most important job to be performed by the transport airplane in the next 25 years is that of over-flying the highways and railroads in opening up to greater use the underdeveloped resources that exist over much of the earth.

"This requires a simple, rugged airplane that can operate from small airports at the lowest possible seat- and ton-mile cost, and that can be operated and maintained dependably with modest facilities and skills. Cargo handling abilities must provide for ready convertibility for varying passenger and cargo ratios from station to station.

"The airplane for this basic job tends to fill the existing equipment gap elsewhere in the short-haul field.

"Higher wing loadings, lighter power loadings and higher speeds have made long-haul passenger transport possible at costs competitive with surface transport. But, unfortunately, this trend has produced the opposite effect over shorter distances, with the result that we now find in many places that airplanes with cruising speeds of 300 m.p.h. require greater scheduled time to fly a route with numerous stops than airplanes with half the cruising speed.

"At the same time, we find that one can fly from coast to coast in the United States on the newest equipment for less money and in less time than from either coast to many points in the interior. Local airline rates in the United States are around 6½ cents per passenger mile *versus* 3½ cents New York-to-California on coach flights. Therefore, in the local service field in the U.S., Europe and similar areas there is a place for an airplane that will achieve the low seat-mile cost now offered by existing equipment only over long non-stop distances.

"There is a lucrative opportunity everywhere for an airplane which can operate at rates comparable to those of the truck or bus. Studies have been made of trucking costs over some of the heaviest traffic routes in various areas of the world. In Colombia, for example, it was found that with the F-1 Safari the total hauling costs of 8 to 9 tons of cargo are in many cases lower than those of the truck. Costs in the combined passenger/cargo version when seating 30 passengers indicate that the local service airlines in the United States could achieve direct costs of 1 to 1.1 cents per seat-mile over distances of 75 to 600 miles, and the direct ton-mile costs for the cargo payload available are lower than those of any existing commercially-operated scheduled air freighter. The indirect and stevedoring costs, which in the United States average about 40 per cent of the total costs, are greatly reduced by the built-in Cargon system designed into the F-1."

AIRFRAME. The airframe structure is all-metal using conventional aluminium alloy materials, and stressed for a maximum gross weight of 45,000 lb.

The wing is of N.A.C.A. 23,000-series aerofoil section. The wing is of all-metal cantilever construction and consists of three main sections: a centre section, incorporating permanently attached nacelles and detachable outer wing panels, and wing-tip panels. The leading edge incorporates boot-type de-icing equipment. Thermal de-icing is optional. The centre section structure consists of two main span-wise beams, conventional ribs, skin-stringer upper and lower surfaces, hinged leading-edge sections (except at the nacelles), and a conventional trailing edge. The basic wing and nacelle is structurally adequate for the optional installation of turboprops. The ailerons have an all-metal frame with fabric covering. Mass balancing is incorporated, together with an irreversible trim tab and balance tab for the reduction of the

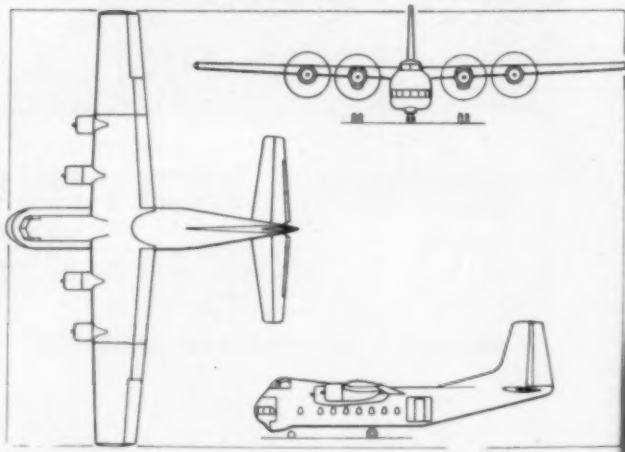
FRYE F-1 SAFARI

Four Wright R-1300 (800 h.p.) or P. and W. R-1340 (600 h.p.)

Dimensions: Span, 109ft 6in; length, 75ft 10in; height, 30ft; track, 27ft; wheelbase, 20ft 6in.

Weights: Empty, 25,678 lb (23,456 lb with R-1340s as freighter); operating, 26,712 lb; payload and fuel, 18,288 lb (10,765-13,240 lb with R-1340s); maximum weight, 45,000 lb (37,600 lb with R-1340s).

Performance: estimated with R-1300s; R-1340 figures in brackets: Take-off, 1,420ft (1,260ft) run to V_2 of 78 (71) kt, and 3,120ft (3,290ft) to 50ft; rated-power climb at s.l., 930 (855) ft/min; cruise at 5,000ft, 161 (153) kt; landing over 50ft, 1,810ft (1,585ft), with 3,020ft (2,645ft) required.



aerodynamic hinge moment. Double-slotted all-metal flaps are fitted, with synchronization provided to prevent asymmetrical flap motion.

The leading edge of the tailplane incorporates provisions for boot-type de-icing equipment; thermal de-icing is optional. The tailplane is of cantilever, all-metal construction, consisting of a continuous two-spar box with conventional ribs and skin/stringers. The elevators are similar in construction to the ailerons; likewise the structure of the fin and rudder is similar to that of the tailplane and elevator.

The fuselage is of all-metal semi-monocoque construction, incorporating frames and longitudinal stiffeners with smooth aluminium alloy sheet covering. Structural provision is included in the fuselage for the installation of 18 windows as well as three emergency exits.

The main cargo-compartment entrance doorway in the nose is 78in high and 106in wide. The cargo floor is parallel to, and 52in above, the ground. Access to the nose doorway is through two vertically hinged clamshell doors incorporating eight windows. The main cargo compartment side door is 75in high and 76in wide, and is on the port side of the fuselage at the aft end of the main cargo compartment. An auxiliary side door is incorporated. A movable bulkhead can be used for partitioning the main cargo compartment. Entrance to the aft compartment is by a door located on the starboard side of the fuselage. The main cargo floor is designed for a loading of 150 lb/sq ft.

Crew entrance and emergency exits are provided by a door 20in wide by 34in high located on the starboard side of the crew compartment immediately aft of the co-pilot's seat. Internal access to the pilots' compartment is by a hatchway in the floor; the hatch covering incorporates a folding ladder which gives access to the main cargo compartment. The cockpit incorporates a V-type, de-iced, impact-resistant windscreen capable of withstanding the impact of a four-pound bird at 191 kt and having double-glazed panels to allow the introduction of heated air for defrosting. Conventional wipers are provided.

The undercarriage is a fully retractable, tricycle gear incorporating four main wheels (one dual set on each side) and steerable nosewheels. Retraction and extension, steering and braking are hydraulic. Automatic safety devices prevent accidental retraction. The landing gear is designed to extend and latch in case of hydraulic failure. Shock absorber struts are conventional, oleo-pneumatic struts. Nose gear wheels are splined to a live axle.

POWERPLANT. The Safari is offered with either of two standard powerplants, although design studies have been made for the Alvis Leonides Major and Lycoming T53 turboprop. The normal units are the Pratt and Whitney R-1340 of 600 h.p. and the Wright R-1300 of 800 h.p. Each is installed as an interchangeable unit on a tubular mounting in an N.A.C.A. cowl, and drives an 11ft 6in Hamilton Standard airscrew.

The lubrication system consists of an oil tank, radiator and oil dilution for each engine. Oil tanks have a capacity of 12½ gallons each.

SYSTEMS. Flying Controls. Flight controls are duplicated for pilot and co-pilot. Conventional flexible cable connections run between the cockpit and control surfaces. Trim controls for rudder, elevators and ailerons, together with position-indicators, are provided.

Hydraulic System. All closed hydraulic circuits have relief valves to prevent undue strain. Satisfactory provisions for bleeding the system are provided. The operating pressure is 3,000 lb/sq in, and hydraulic fluid is of C.A.A.-approved inflammable type. The system is served by pumps on each of the four engines, drawing from a hydraulic reservoir which is readily accessible for filling, draining and removal, and which incorporates a sight-gauge. A hydraulic emergency hand pump is provided in the pilots' compartment accessible to the co-pilot.

Fuel System. This is designed to allow fuel to flow from any tank to any engine. Four bag-type fuel tanks are mounted in the centre section wing. Normal fuel capacity will be 1,000 gallons; structural provision for an additional 500 gal is made.

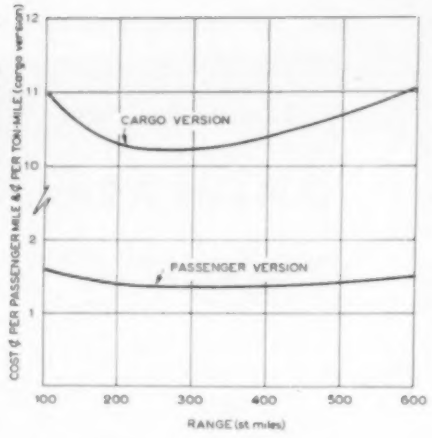
Electrical System. This is basically a single wire grounded system operating on 24 to 28 volts D.C. The system is based on the Aircraft Industries Association Manual for Aircraft Electrical Installation. All power sources are connected to a main bus through relays controlled from the cockpit; secondary bus-bars connect to the main bus through circuit breakers. Essential loads are connected to the main bus, non-essential loads to the secondary bus. A switch connects an emergency bus-bar distribution system directly to the battery.

Power supply is from four engine-driven 30 volt, 100 amp generators. Two 12-volt, 88 amp-hr batteries are installed; instruments and radio equipment requiring 110-volt or 26-volt A.C. are supplied by either of two 24-volt, 500-VA inverters on the flight deck. A 100-VA inverter provides emergency power for the flight instruments. A three-pronged high-capacity connector on the fuselage permits 24 volt D.C. to be supplied from an external source.

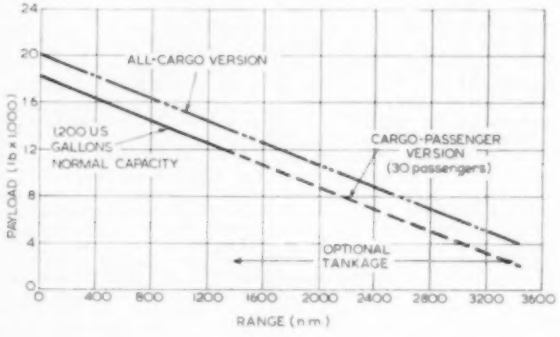
Radio. The basic radio communication and navigation system consists of one 25 watt V.H.F. transmitter, 118-135 m/cs, and one V.H.F. communications/navigation receiver, plus structural provisions for the following equipment (this equipment will be optional and will depend on individual customer requirements): duplicate 25 watt V.H.F. transmitter, 118-135 m/cs; V.H.F. communications/navigation receiver, 108-135 m/cs; marker beacon receiver, 75 m/cs; H.F. transceiver with automatic aerial tuning unit, 2-18 m/cs; two A.D.F. receivers, 90-1,750 k/cs; two glide slope receivers, 300 m/cs; public address amplifier; audio isolation amplifier.

Air Conditioning System. The heating system is capable of maintaining a temperature of at least 75 deg F with outside air temperature of minus 50 deg F. The system incorporates a combustion heater, cold air being taken through ducts from an air intake scoop. A ground blower is installed in the fuselage heater from which heated air may be supplied on the ground.

ACCOMMODATION. Cargo Rôle. The Safari, its makers claim, introduces a new approach to cargo handling by being specifically adapted to modern mechanical techniques. It lends itself to a cargo preloaded-pallet system that permits simultaneous loading and unloading, a feature of particular value to the operator interested in tightly scheduled flights in which turn-around time can be of great importance. This is accomplished through doors located at both ends of the cargo compartment (clamshell nose-doors and a big door, 6ft 3in by 6ft 4in, on the port side aft at the same floor height) which give clear access for the insertion and removal of pallets by means of mechanized loading and unloading procedures at both ends of the cargo compartment.



Payload/range is for R-1300-powered F-1 at 8,000ft with 45-min reserve; costs are for R-1340-powered aircraft, A.T.A. method, no wind, 9-min manœuvre, 30-per-cent residual, depreciation over a period of 7 years.



The loading of the pallets (which are provided in various sizes) may be accomplished from a truck, an inclined ramp, or by means of a special dock. Flared lead-in devices located at the floor edge guide the pallet wheels into longitudinal tracks which run the full length of the compartment, and which incorporate locking pins. Six main, longitudinal tracks in the floor of the cargo compartment carry all cargo loads into the structure. Opposite the aft cargo door there is a set of transverse tracks which intersect the longitudinal main tracks with mating guides to permit the pallet wheels to caster for side-wise insertion or removal from the main longitudinal tracks.

For those operators who employ methods of handling not involving pallets, the floor is covered with readily replaceable panels surfaced with an abrasion-resistant material. Tie-down is effected by removable rings locked into the longitudinal tracks.

Combination payloads of cargo and passengers may be accommodated by dividing the fuselage interior into forward and aft compartments. Separation of these two sections is accomplished by means of an easily movable bulkhead which permits broad variations of space. The bulkhead as well as passenger seats are fastened with special fittings which mount on the longitudinal main tracks.

Passenger Rôle. The standard arrangement is based on the use of nine rows of five-abreast seats which are each 18in in width and leave an 18in aisle down the centre. These seats are attached to the longitudinal cargo tie-down rails at a pitch of 39in, and each row is opposite one of the nine windows on each side of the cabin. The windows are 25in high and 16in across. The lower half of each of these elliptical windows is extended horizontally (as in the Caravelle) to provide increased visibility below the horizon.

The rectangular cross-section of the cabin (unusual in an airliner) provides ample space for carry-on luggage compartments below the ceiling on both sides of each of the nine ranks of seats. Since carry-on luggage will be stowed in the compartment nearest to each passenger's seat, traffic flow is not interrupted at the cabin entrance.

These compartments, together with insulated wall-panels, individual reading lights, air outlets and window curtains form units conforming to the 39in "dimensional module," to which the fuselage is designed and built. Carpets, ceiling liners with lighting fixtures, and all necessary trim strips also are cut to this same 39in dimension. An all-passenger version thus contains nine pairs of these "modular kits." In the combined cargo-passenger version, a movable bulkhead separating the passengers from cargo may be installed adjacent to the forward edge of the foremost modular unit.

Since the cabin of the Safari extends to the nose of the fuselage, a unique design feature in the form of a "vistaramic" lounge has been incorporated. The eight windows in the nose provide an unobstructed forward view which can be enjoyed by practically all the passengers, and not only those in the six seats facing the "vistaramic" window. Where conversion is contemplated the lounge windows are installed in the clamshell doors. In a permanent passenger version they can be installed in a fixed nose structure.

Airliners of the World

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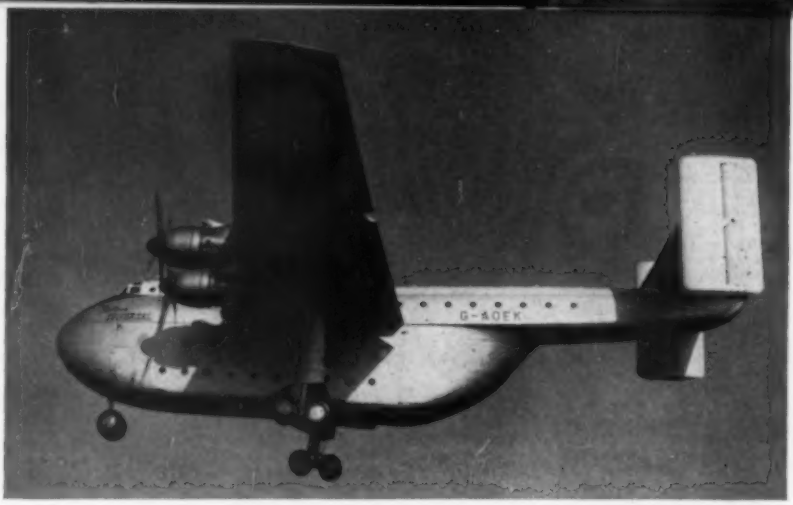
BLACKBURN AND GENERAL AIRCRAFT, LTD., BROUGH, E. YORKS.



TRANSPORT aircraft, alone among the various types used by the R.A.F., are equally suitable in military or civil applications. It is not surprising, therefore, that since embarking on the initial design work of the Beverley military transport in 1946, Blackburn and General Aircraft have been considering the airline requirements for its civil counterpart, the Universal. The Beverley includes many features suggested as desirable by the various airlines with whom the project has been discussed, and many also which the A.R.B. have indicated that they would like to see in its civil version. The differences between the military Beverley and the civil Universal are therefore minor.

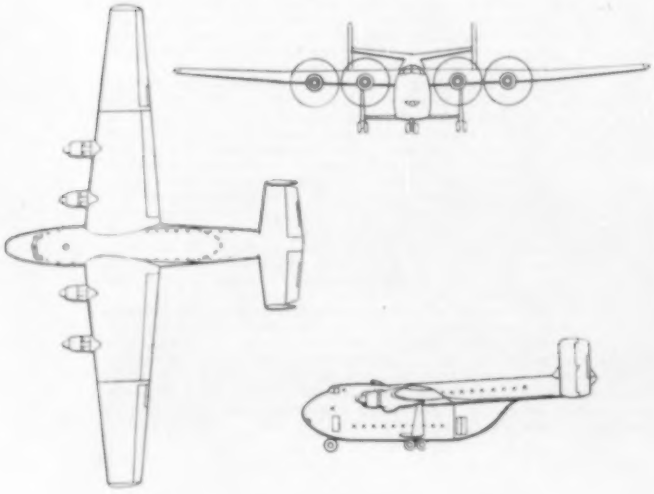
In considering the requirements for the Universal, the designers could call on little airline experience, as no exactly comparable aircraft had ever been operated commercially. They therefore tackled the problem by considering the aircraft as a "cargo transport vehicle," and building into it all the features one would expect to find in any such vehicle. The prime consideration was, of course, low cost—low prime cost and low operating cost. Even now, despite the increase in labour and material costs since 1946, the price is £425,000, a very low figure—£3 per lb—for an aircraft of 143,000 lb gross weight.

The standard S.B.A.C. method for assessing operating costs was derived to suit sophisticated passenger aircraft, and Blackburn therefore use a modified version of this formula; it shows an operating cost of under 8d. per long-ton nautical mile for ranges from 200 to 700 miles. This should allow the introduction of commodity and other special rates comparing very favourably with the existing surface rates in many parts of the world.

Simplicity and robustness have been carefully considered throughout the design and development. The structure is particularly simple, and only well-tried equipment and mechanisms have been used. Where possible the aircraft has been "simplified by omission"; there are, for example, no undercarriage retraction, no pneumatics and no pressurization, and this principle has been applied wherever practical in the design of all the services.

Conceived as a relatively short-range aircraft (its operating costs are attractive for stages up to 1,200 miles or so) the Universal had obviously to be designed to operate from short, unpaved airstrips. With a take-off field length of 1,260 yd, and a full-load landing run of only 240 yd, it meets the small-strip requirement; and with a tyre pressure of 50 lb/sq in, and an equivalent single-wheel load comparable with that of a DC-3, the Universal's airstrip demands are very modest.

The size of the hold (40ft by 10ft by 10ft) gives flexibility of carrying capacity so that loads will rarely have to be refused on account of their size—particularly since loading can be achieved without difficulty through the big rear doors. The 22-ton payload undoubtedly provides a lifting capacity unequalled by any other commercial aircraft.



AIRFRAME. The Universal's massive fuselage has a gross volume of more than 7,500 cu ft, and is divided into three distinct sections: (1) the freight hold, (2) fuselage tail, (3) the flight deck.

The freight compartment is designed as a huge cargo container of constant section, 40ft long, 10ft high, and 10ft wide, with a total floor space of 505 sq ft. The maximum permissible load is above the maximum disposable load of the aircraft. Lashing points and rails are generously provided; the former may be used as seat attachments if required. The floor is divided into five sections of differing strengths; the main central "heavy" floor, for example, has a general strength of 450 lb/sq ft, and can accept a vehicle axle-load of 12,500 lb.

There is unobstructed access *via* the rear doors, which are 11ft wide, and the height of the floor from the ground varies from 4ft 6in to 6ft depending on loading. There is provision for an electric winch, vehicle loading ramps, and a gantry.

The fuselage tail has a floor area of 355 sq ft with a floor strength of 80 lb/sq ft, generously provided with lashing fittings identical to those in the freight hold—i.e., they can be used as seat attachments. There is a ventral hatch (6ft 9in by 4ft) for loading or dropping (passenger access is *via* the flight deck); as an alternative to this hatch a 4ft 6in square side door can be provided.

The flight deck can be laid out to suit individual requirements. With a two-man crew, the freight compartment behind the flight deck has a gross volume of 430 cu ft and a floor area of 145 sq ft.

The wing is of 21 per cent thickness/chord, and is a two-spar structure, with a heavy-gauge skin supported by spanwise stringers. The wing comprises four main units—two centre wings and two outer wings. Provision is made for four twenty-man dinghies in each centre wing. The leading edges are provided with double skin for thermal de-icing and a crawlway is provided in the leading edge of each centre wing for access, in flight if necessary, to controls and equipment, and to the accessory bays behind the engines. Frise-type metal ailerons with geared tabs are fitted, and the single-slotted metal flaps, one on each side, are operated by three screwjacks each.

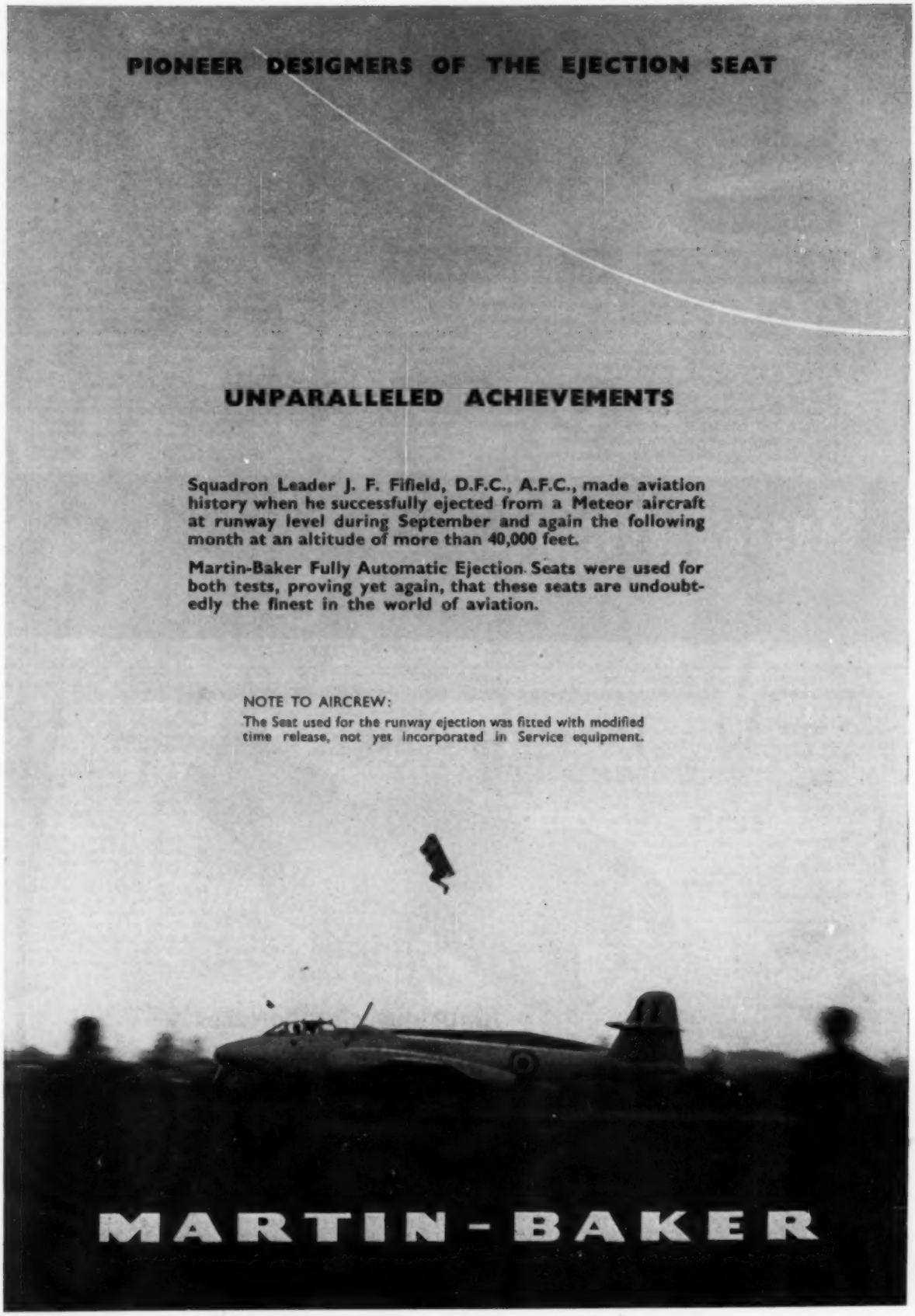
The tailplane is a two-spar structure, incorporating a double-skin leading-edge for thermal de-icing; the elevators have geared tabs. The two vertical fins are each two-spar structures, all-metal with double skin leading-edges for thermal de-icing. The rudders have geared tabs and are of conventional construction.

Each main undercarriage consists of a vertical shock absorber, a horizontal sponson, and a four-wheel bogie. For normal operation from runways, grass or dirt strips, tyres of 82 lb/sq in pressure are used. For operation from very soft strips tyres identical to those used on the nose wheel and of 50 lb/sq in may be fitted. A different design of wheel is used for each type of tyre, but both incorporate identical quick-change attachments. Dunlop Maxaret anti-skid devices are fitted to the hydraulic disc brakes. The nose undercarriage is steerable, having twin wheels fixed to a live axle. Steering range is 90 deg. The nose-wheel is self-centring, with lugs provided for towing. Nose-wheel tyre pressure is 57 lb/sq in.

POWERPLANT. The Universal has four Bristol Centaurus 873 18-cyl., radial, air-cooled, sleeve-valve piston engines of 3,150 h.p. The 873 is an uprated Centaurus 173—the engine of the military Beverley in service with the R.A.F.—the 300 h.p. increase in power being achieved by direct fuel injection. The engine and its installation are similar in all but minor details. The higher powers allow the take-off weight to be increased by 8,000 lb to 143,000 lb. The powerplants are unhanded interchangeable units, each consisting of four parts: airscrew group, engine-change unit, mounting bay, and accessory bay. The latter three are separated by firewalls.

The airscrew is a de Havilland Hydromatic unit of 16½ft diameter with four hollow steel blades, electrically de-iced. The spinner and fan are of resin-bonded glass-fabric construction. The airscrews are constant-speeding, feathering, auto-coarse-pitching reversing units similar to those fitted to the Bristol Britannia (page 23). The engine-change unit comprises the Centaurus engine with its associated cowlings, cylinder baffles, exhaust pipes, dynamic mounting ring, etc., designed for removal as a unit. The mounting bay lies between the shoulder-cowl on the engine-change unit and the firewall on the accessory bay. It contains the air intake system, controls and services, and tubular mounting structure. The accessory bay is aft of the firewall and houses the oil tank and the majority of the oil system, the fire extinguishers, fuel system components, controls, accessory gearbox, and the wing de-icing duct.

SYSTEMS. Air Conditioning. There are three systems, one for each main structural compartment: flight deck, freight hold and fuselage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Squadron Leader J. F. Fifield, D.F.C., A.F.C., made aviation history when he successfully ejected from a Meteor aircraft at runway level during September and again the following month at an altitude of more than 40,000 feet.
Martin-Baker Fully Automatic Ejection Seats were used for both tests, proving yet again, that these seats are undoubtedly the finest in the world of aviation.
NOTE TO AIRCREW:
The Seat used for the runway ejection was fitted with modified time release, not yet incorporated in Service equipment.
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The Model S.122 Form 4 is a high pressure transmitter having ranges of from 0-400 p.s.i. up to 0-6000 p.s.i. The transmitter is contained in a die-cast aluminium case and consists basically of a special form of Bourdon tube which, when under pressure, moves laterally, causing a change in the position of a contact arm wiping across a resistor.
The resultant variations are led away from the transmitter through a three-pin plug, and are fed to a ratiometer indicator operating from the nominal 24 volt supply. The instrument is substantially independent of variations in supply voltage. The working life of this transmitter is unaffected by large and high frequency pulsations in the pressure supply.
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Airliners of the World

UNIVERSAL

tail. Each system is designed to provide a temperature of not less than 60 deg F in outside temperatures of minus 36 deg C at heights of up to 8,000ft. The flight deck system has twin electric fans delivering fresh air through a 50,000 B.Th.U/hr heater. The freight hold system is served by the leading-edge ram air intakes delivering through a 400,000 B.Th.U/hr heater. The fuselage tail system is served by ram air delivered through a 250,000 B.Th.U/hr heater mounted between the centre-wing upper surface and the fuselage roof.

Heat output is varied by fuel supply, and automatic mass-flow control is fitted, allowing the system to be used with the heaters unlighted when ventilation only is required. Oxygen supply for crew and passengers is provided.

Fuel System. A total of 3,600 gallons of fuel is carried in four tanks, two per wing. There is structural provision for two other tanks per wing, increasing total tankage to 6,880 gallons. The fuel system is simple and conventional. Pressure refuelling (300 gal/min) and pressure off-loading (100 gal/min) is provided, the connections being positioned on the side of the fuselage 4ft from the ground. Provision for gravity refuelling is made. Fuel gauges are of the "capacitance" type. For the standard water-methanol injection system, four separate 10 gal systems are available, one for each engine. The oil supply for each engine is independent, contained within each mounting and accessory bay. Each tank is of 45 gal capacity; additional tankage is available to match the endurance with 6,880 gal fuel.

Hydraulic System. This operates at 2,500 lb/sq in. For the flying control boosters, two completely independent systems are provided to guard against possible failure. Each system consists of an accumulator charged by the two engine-driven hydraulic pumps on one side of the aircraft. Hydraulic supply for the wheel-brakes is delivered from one system at 1,500 lb/sq in through a reducing valve, and power for the nosewheel steering is taken from the same system.

Electrical System. This works at 24 volts D.C. and is supplied by four 6 kW engine-driven generators. Two 24 volt 80 ampere batteries are fitted (of sufficient capacity to start the engines). A compact electrical panel on the flight deck provides voltage control, houses the main distribution busbars, and the circuit breakers and fuses. A.C. for instruments and autopilot is provided by two inverters; independent inverters are provided for radio and radar. Two 15 kVA engine-driven alternators (inboard powerplants) provide power for airscrew de-icing.

De-icing System. Three Lucas petrol-fired combustion heaters, two of which are installed in the leading-edge of the starboard stub wing and the other in the port stub wing, supply the wing leading-edges.

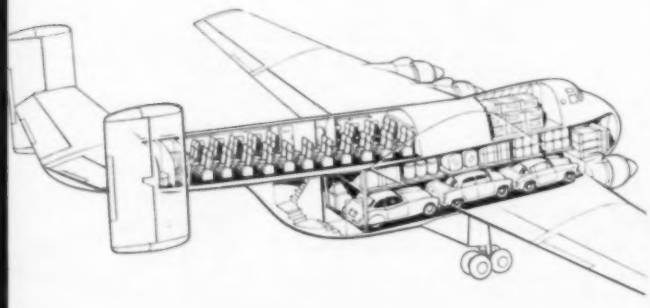
Each is of 400,000 B.Th.U/hr. The tail system is similar, being provided by two heaters in the rear of the tail compartment. The engines are fitted with oil-heated throttles and hot-air de-icing; airscrews and pitot heads are electrically de-iced, and alcohol sprays serve the windscreens.

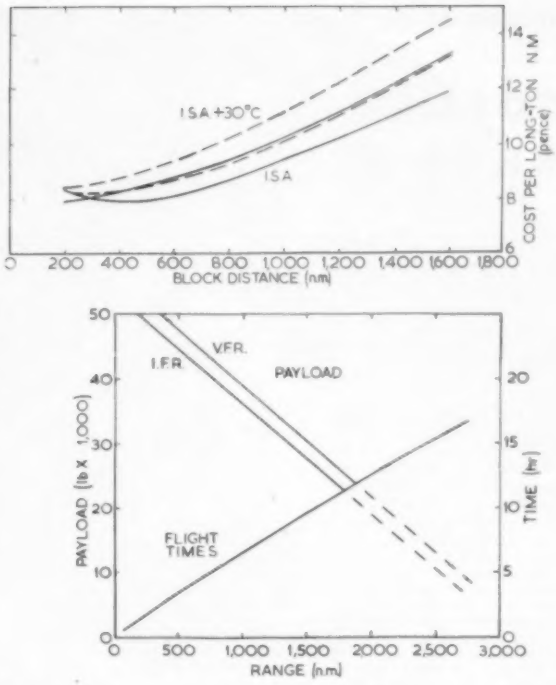
Flight Deck. Cockpit accommodation is offered to suit individual requirements. The aircraft can be operated by a crew of two; space in the freight compartment behind the two pilots can readily be used for a radio operator's station and a navigator's station, positioned back-to-back on the port side with the main electrical panel (which is situated on the forward side of the pilots' compartment bulkhead behind the co-pilot in the two crew version) installed on the starboard side opposite. Access to the flight deck is *via* an internal ladder from the entrance door on the bottom port side of the fuselage. Dual control is provided, and each pilot has his own throttle and r.p.m. control on his outboard side. Similarly, individual trim control boxes are provided for each pilot.

In general, crew accommodation is exceptionally spacious and visibility is excellent.

Radio equipment is provided to the requirements of each operator.

Flying Controls. Power assistance is provided on all controls by duplicated hydraulic boosters of Fairey design. Push-pull rods are connected directly to the control surfaces through these boosters with a linkage connection to the servo valves. Feed-back ratios are: aileron 1 : 14, elevator 1 : 10, rudder 1 : 5. Control is smooth with no backlash. A Smiths rate-sensitive electronic automatic pilot is fitted, and provision is made for coupling it with the I.L.S. for automatic landing. Control locks are provided, designed in such a way that only one engine can be opened up to full power with the locks applied. The flaps are operated electrically, with duplicated motors driving ball-bearing screwjacks at each flap hinge. Flap positions are "gated" as follows: flaps up, 0 deg; take-off, 15 deg; landing, 40 deg.





In the cost curves (top) the broken lines include I.F.R. allowances.

PAYLOAD ACCOMMODATION. The Universal is basically a cargo aircraft, but its vast capacity and three-compartment layout lend themselves to any number of different rôles. Blackburn have provided more than capacity: they have shown how the best use can be made of it by proposing a variety of workable schemes.

Six of these are described here. The one which undoubtedly displays the Universal's remarkable flexibility of payload is that illustrated in the accompanying diagram: (1) This shows the aircraft arranged for the accommodation of 58 passengers on the upper deck in the fuselage tail; freight accommodation at the rear of the flight deck; and heavy freight —including four cars—disposed in tiers (the cars being at floor level) in the main freight hold. (2) The maximum number of passengers that can be carried for short-range operations is 160, achieved by filling the fuselage tail and the main freight hold with seats. Ample baggage capacity remains aft of the flight deck. Various other seating arrangements, from 96 passengers upwards, are of course available. (3) As a container-carrying aircraft, the whole of the main freight hold may be filled with preloaded pallets, of various weights. Unloading and loading of a full load, of the order of 50,000 lb, can be accomplished in half an hour with this arrangement. Where no cargo handling gear is available, large unit loads (unwheeled) can be conveniently handled with a gantry system which may remain in position with the rear doors closed. (4) For new-car delivery, the use of pre-loaded Cargons—of the type used in New Zealand by Straits Air Freight Express—permit the loading of seven cars in the main freight hold: one row of four above one row of three, with generous space for additional freight. (5) All the available space—i.e., 7,500 cu ft—provides ample space for general freight, or single commodity cargoes such as meat or unassembled car parts. (6) As an ambulance there is space for 104 casualties; 70 stretcher cases in the main freight hold, arranged in tiers, and 34 sitting cases in the fuselage tail.

A typical weight break-down for item 1 above, as illustrated in the diagram, is as follows: 58 passengers at 165 lb each, 9,570 lb; baggage at 45 lb each, 2,610 lb; three cars at 3,500 lb each, 10,500 lb; freight at 10 lb per cu ft, 22,330 lb; allowance for stewards, pantry, freight pallets, racks, lashings, toilets, etc., 4,990 lb. Total 50,000 lb.

COMMERCIAL HISTORY. The Universal's greatest commercial accomplishment to date was the airlifting of 129 tons of bulky oil equipment between Umm Said, the Arabian oil port, and Fahud, 365 miles away. For geographical and political reasons, movement by sea and land of this equipment would have been difficult, if not impossible, and the size and bulk of some of the individual units (one item weighed 16½ tons and measured 21½ft by 9ft by 8½ft) could not have been carried by any other type of aircraft.

BLACKBURN AND GENERAL AIRCRAFT UNIVERSAL

Four Bristol Centaurus 873 of 3,220 h.p.

Dimensions: span, 162ft; length, 99ft 5in; height, 38ft 8in; gross wing area, 2,916 sq ft; track, 33ft 5in.

Weights: basic operating weight, 81,740 lb; disposable load, 61,260 lb (59,610 lb with low-pressure tyres); payload, 50,000 lb; max. zero-fuel, 135,000 lb; max. landing, 138,000 lb; max. weight, 143,000 lb.

Performance: balanced field length, 3,780ft; S.L. rate of climb, 765 ft/min; recommended cruising speed, 173 m.p.h.

Airliners of the World

GOLDEN ARROW

CONVAIR, DIVISION OF GENERAL DYNAMICS CORP., SAN DIEGO, CALIFORNIA

FOR some years the Convair Division of General Dynamics Corporation have been wondering what the future holds for them in the commercial-aviation business. They have now had to abandon many important fields to competitors and their existing production of Metropolitans (page 35) cannot reasonably be expected to extend into 1958.

At present they have put all their eggs into the medium-range jet basket with a design looking rather like a scaled-down DC-8, with the designation Convair Golden Arrow. Studies have led Convair to a rather larger size of aeroplane than the equivalent medium-range projects at Boeing and Douglas. This partly results from the choice of engine—and it is also owing to the use of this powerplant that the design was not offered to operators a year earlier, before Lockheed began to sell Electras. The engine is the General Electric CJ-805 turbojet of 10,500-11,000 lb thrust. This is a derated commercial variant of the military J79, a single-shaft, high-compression engine with variable stator blades; it is an attractive proposition by virtue of its high thrust and light weight. General Electric are strenuously pursuing a redesign policy on the military J79 which should result in an engine acceptable to commercial operators.

The airframe structure is quite advanced in concept, and detail design has already reached a late stage. The fuselage is formed from two principal radii merging gently with each other, the basic cross-section over the outer skin being 149in high by 138in wide. There are three main spanwise webs in the wing, with integral tanks housing a total of 8,992 gal (70,000 lb) fuel. Multi-section area-increasing flaps are provided extending right out to very small ailerons at the wing tips, which are supplemented by spoilers (for use as speed brakes or for lateral control) ahead of the flap. A conventional bogie undercarriage is fitted and an unusual feature is the notching of the elevators to allow for rudder movement. Although the wing-loading is by no means high Convair are investigating applications of flap-blowing and boundary-layer control.

A typical seating plan is shown below. In this form the width of each double seat-unit is 50in, so that the central gangway has a width of no less than 28in. With five-abreast seating (45.1in twins and 64.4in triples) the gangway shrinks to 18.5in, but up to 113 passengers can be carried without reducing the seat-pitch. Windows are elliptical, one per frame, one on each side forming a large emergency exit. Main entrances are to port, fore and aft, with service doors or emergency exits opposite. All are outward-opening plug-type structures, the main doors being approximately 72in high. An optional addition at the forward main door is a novel design of integral stairway which folds into a pressure box under the floor and has no effect on the arrangement above the floor. Door sills are at 9ft 7in. Under the floor are large freight holds ahead of and behind the wing. Each compartment is served by a plug door on the starboard side; the interior height of each hold is 48in and the total capacity of both, 850 cu ft. The design cabin pressure differential is 7.5 lb/sq in (8,000ft at 35,000ft).

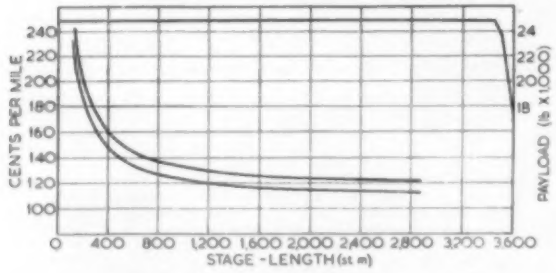
The first large order which allowed Convair to go ahead was placed by Howard Hughes, on behalf of T.W.A. For Hughes, Convair renamed the machine—it had originally been designated Skylark 600—and agreed to consider the use of gold anodized skin. Apart from T.W.A.'s 30, Delta have bought 10 and other operators are well advanced in discussion. Development is jointly the responsibility of Convair, G.E. and the Hughes Tool company; the prototype is to fly in 1959 and deliveries are to start in 1960, at £1.07m without spares (one CJ-805, £44,600).

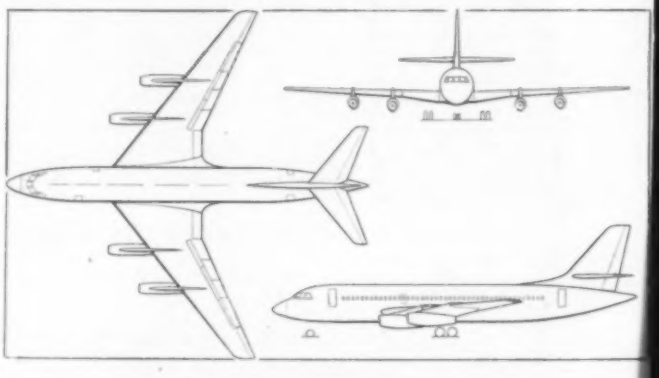
CONVAIR GOLDEN ARROW

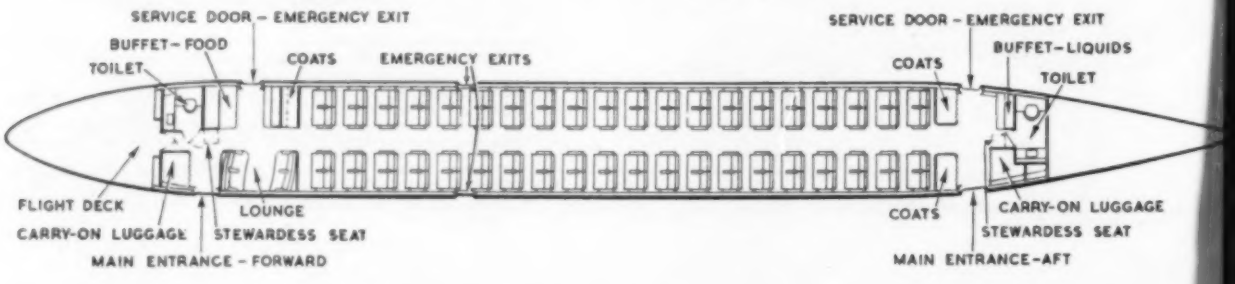
Four General Electric CJ-805 Turbojets

Dimensions: Span, 118ft 4in; length, 124ft 2in; height, 37ft 7in; basic wing area, 2,000 sq ft; root chord, 27ft 0¼in; sweep at 0.3 chord, 35 deg; thickness/chord ratio, 11 per cent (root), 9 per cent (break), 7 per cent (tip); track, 19ft 6in; powerplant distance from centre-line, 22ft 3in (inboard), 35ft 6in (outboard). **Weights:** Empty, 78,100 lb; basic operating weight (with crew), 81,000 lb; payload, 21,700 lb comprising 13,200 lb passengers (80) and 8,500 lb freight (850 cu ft); structural design payload, 25,000 lb; take-off weight less fuel, 102,700 lb; zero-fuel weight, 110,000 lb; landing weight, 123,500 lb; maximum weight, 178,500 lb. **Performance** (estimated): Field length for take-off (see p. 10), 8,400ft; take-off distance to 50ft at 140,000 lb using $1.2V_S$, 5,100ft; climb at max. climb power at 140,000 lb, 33,000ft in 12 min (note: height may be deliberately restricted according to cruise procedure adopted); cruising performance, max. cruise power at 140,000 lb, 479 kt e.a.s. at 170,000 lb at 35,000ft at 0.044 n.a.m./lb or 540 kt at same weight at 15,000ft at 0.023 n.a.m./lb or 503 kt at 35,000ft at 120,000 lb at 0.045 n.a.m./lb; range with "ramp weight" of 140,000 lb and 34,000 lb fuel (including 1,625 lb for manoeuvre and take-off, 875 lb for reaching climb speed with no distance made good, climb to 25,000ft at max. climb power, cruise at 25,000ft at max. cruise power, descent, zero wind, 10,000 lb reserve fuel), 675 n.m. (778 st.m.); design limit of V_C/M_C, 375 kt e.a.s or Mach 0.89; landing field length, 5,350ft.

Payload/range (below) based on 10,000 lb reserve fuel (for 260 n.m. at 25,000ft plus 45 min hold at 15,000ft); d.o.c. curves are based on seven-year (upper curve) and ten-year depreciation; the seating plan shows a standard 80-passenger configuration.

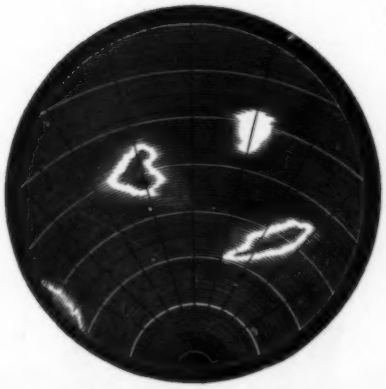






SEEING AHEAD . . . . . .

The growing use of high-speed aircraft has focussed attention on the value of Search Radar for weather-avoidance. Already, the BOAC Britannia Fleet is being fitted with EKCO Search Radar, a 3cm equipment which provides early warning of potentially dangerous cloud formations, warning of high ground in the flight path, and map-painting to assist navigation.



The P.P.I. display shows a sector of space ahead of the aircraft. Cumulo-nimbus cloud cores are indicated by white areas and particularly turbulent regions by black areas surrounded by white.

With a range of 120 miles, Ekco Search Radar Type E120 incorporates the Iso-Echo Contour feature which facilitates distinction between dangerous and less dangerous cloud formation. The P.P.I. display shows two contours, one corresponding to the minimum detectable signal level and the other to a pre-determined amplitude above this level.

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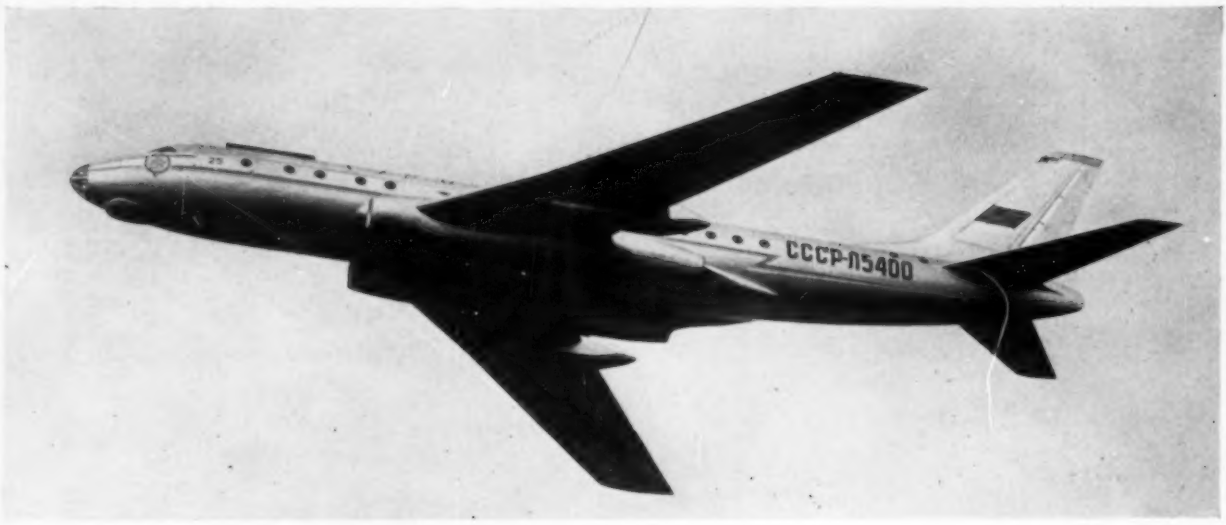


Airliners of the World

Tu-104

SOVIET NATIONAL FACTORIES; A. N. TUPOLEV, CHIEF OF DESIGN

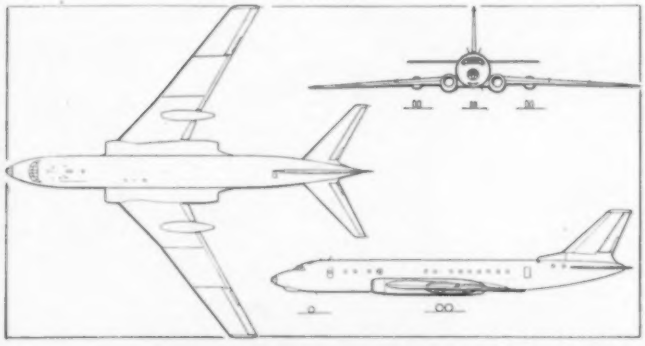
EVEN six months ago the thought of the Soviet Union becoming a competing nation in the jet-liner business had probably crossed very few Western minds; but, we are informed, Russia intends to make the Tu-104 (itself only revealed 14 weeks ago) available to anybody who wishes to buy it.

Of the aeroplane itself much has already been written, and we have no cause to retract anything which appeared in our issues of March 30 and April 6. It clearly owes much to Russian bomber designs and may even employ common components and accessories. Most of what appears below, however, is new. Basically the Tu-104 is a conventional structure of a configuration already well known. Power is provided by a pair of large axial turbojets—not of the by-pass type—rated for commercial use at 14,850-14,880 lb. This engine is well developed and military versions, with ratings some 2,500 lb higher, are being mass-produced. Particular features of the airframe are the four large flap sections (split inboard and a slotted-cum-Fowler pattern outboard), four wing fences, fixed tailplane, an exceptional array of aerials (suppressed and otherwise) and provision for a braking parachute. In the spacious flight deck the captain and co-pilot are seated ahead of an engineer (if carried) and radio officer; a navigator works in the transparent nose.

Payload Accommodation. The flight deck is self-contained, complete with "amenities" and its own door, and is separated from the rest of the interior by a pressure bulkhead, with a small door, at about station 260. From this point the cabin is unobstructed back to the rear pressure dome at station 1,212, although the hump of the thick wing centre-section raises the level slightly between the strong frames at the leading and trailing edges of the wing box, at stations 449 and 558. Usable length is 952in and floor width about 113in.

In the floor-plan shown the Tu-104 is fitted for 54 first-class passengers, but in ordinary airline service there is no doubt that arrangements could be worked out providing for at least 70. In the rear cabin are baggage racks formed from nets supported on a metal frame. In addition there is a capacious hold under the floor both ahead of and behind the wing, with a combined volume of approximately 1,000 cu ft. In all the Tu-104s so far examined each passenger has the use of an individual oxygen hose. Design dP is about 7.5 lb/sq in.

Commercial History. According to a Polish source the first machine was built in production jigs and flew on June 17 last year. The pre-production aircraft, of which three have visited Britain and Switzerland, have logged some hundreds of hours on route-proving flying within the Soviet Union, including trans-Siberian flights to Vladivostok. It has been officially announced by the Soviet commercial operator, Aeroflot, that the Tu-104 will be operated by them in numbers as a standard type. The first services will be Moscow - Novosibirsk - Khabarovsk (stage lengths of 2,100 and 2,250 statute miles, respectively) starting this summer. Delivery to non-Russian purchasers is offered in 1958 at the remarkably competitive price of £425,000.



The seating plan below shows a 54-seat first-class Aeroflot configuration, with lounges forward fitted with tables and facing double seats. A typical standard (tourist) interior seats 72.

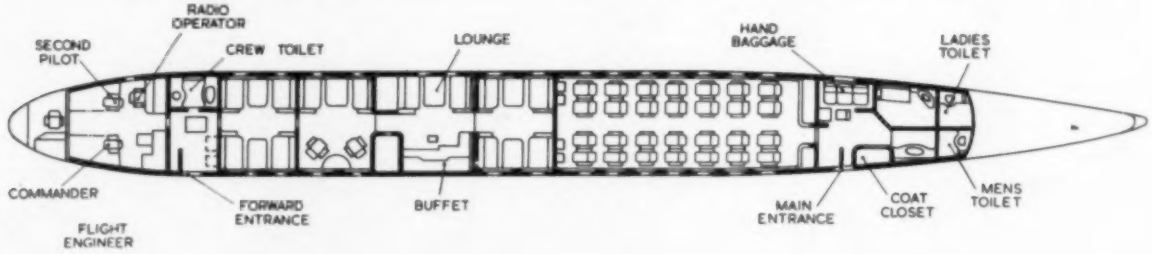
Tu-104

Two turbojets of 14,858-14,880 lb thrust.

Dimensions: Span, 114ft 10in; length, 121ft 4½in; overall height, 39ft 4½in; gross wing area, 2,023.6 sq ft.

Weights: Not stated, but approximately 130,000 lb; fuel capacity is 7,469 gal and payload 15,400 to 22,050 lb.

Performance: Field length required at S.L., i.s.a., about 7,000ft; range, cruising at 497 m.p.h. at 32,800ft with typical allowances and 22,050 lb payload, 1,985 st. m.; operating ceiling, 39,370ft; single-engine ceiling 16,404ft; maximum cruising speed, 559 m.p.h.; climb to 36,090ft in 15 min.



Airliners of the World

PRINCE

HUNTING PERCIVAL AIRCRAFT LTD., LUTON, BEDS.

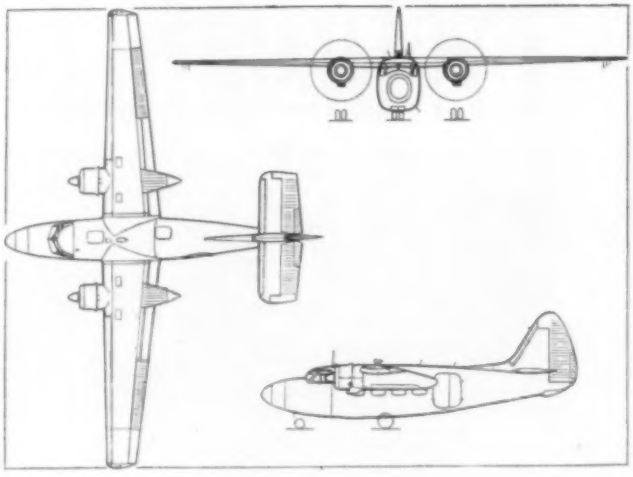
ALTHOUGH most of the Princes so far sold are engaged upon specialized functions—such as photography, prospecting, surveying and radar calibration—the qualities of the Prince 5 are such that it has strong appeal to a wide variety of airline operators. Some of its advantages may be listed as follows: the interior of the cabin is a completely unobstructed volume measuring 20ft × 5ft 6in wide × 6ft 1in high with a door 5ft 2in high × 4ft 2in wide admitting directly to the floor, which is close to the ground; the airframe and powerplants have been extensively developed and proved in arduous service in every part of the world; and the short-field performance, particularly on one engine, is outstanding.

The airframe is generally quite conventional. Metal is used throughout and the control surfaces are skinned with fluted sheet, as is customary with aircraft from this manufacturer. Power is provided by two 540 h.p. Alvis Leonides 503 engines each of which is a nine-cylinder radial with a geared drive and supercharged to give a maximum weak-mixture power of 325 h.p. at 11,250ft with a consumption of 23.5 gal/hr. The airscrews are three-blade de Havilland units equipped for feathering and, if required, for braking. In the Prince 5 twin wheels are mounted on each of the main legs which are pneumatically retracted backwards into the long nacelles. The twin nosewheels also retract to the rear. Pneumatic actuation is likewise employed for the flaps, which are of the slotted type. Fuel is housed in bag tanks on each side of the engine nacelles, the inner tanks each being of 53-gal capacity and the outers of 66 gal, giving a total tankage of 238 gal.

Provision is made for a flight crew of two and dual controls can be fitted. According to requirements radio equipment can be specified to several schemes, although the standard equipment includes such well-known sets as the STR.12, AD.97/108 and AD.7092; optional equipment includes I.L.S. and the Sperry Zero Reader. Extensive development in both military and "outback" civil fields has led to very extensive provision for easy maintenance. Protection against icing is provided by Goodrich inflatable boots on the airframe and fluid systems for the airscrews and windscreen.

The interior layout shown in the diagram is typical for a 12-seat passenger Prince. Seats can face fore or aft and are stressed to 12 g. Baggage or freight can be carried at either end of the fuselage. For heavy-dropping purposes the Prince can be flown with both halves of the main cabin door removed.

As a result of its extensive background of refinement, both aerodynamic and structural, it is expected that the Prince 5 will receive a C. of A. in all normal categories at 13,500 lb. Earlier versions of the Prince are, of course, fully certificated and are in widespread use.

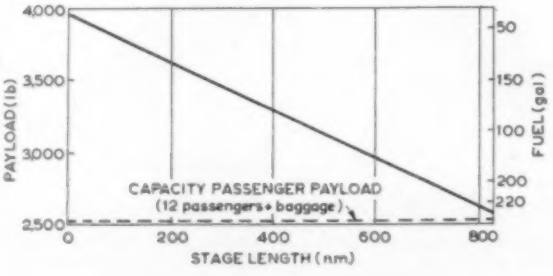


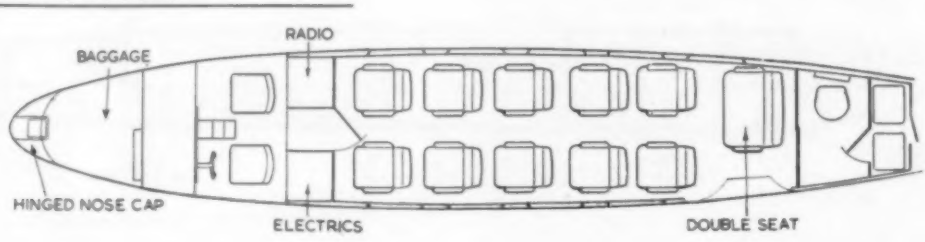
HUNTING PERCIVAL PRINCE V
Two Alvis Leonides 503 of 540 h.p.

Dimensions: Span, 64ft 6in; length, 46ft; height, 16ft; gross wing area, 400 sq ft; track, 16ft 6in; wheelbase, 12ft.

Weights: Empty, 8,545 lb; furnished for 12 passengers (typical), 8,953 lb; disposable load, including 1,670 lb fuel and 2,668 lb payload, 4,547 lb; maximum weight, 13,500 lb.

Performance: Take-off to 50ft, 2,150ft (2,800ft using "safety" technique); continuous climb to 6,000ft, at least 970ft/min; w.m. cruise at 13,000 lb at 11,000ft, 166 kt giving 3.6 a.m.p.g.; economical cruise at same weight at 8,000ft, 132 kt, giving 4.45 a.m.p.g.; landing from 50ft, still air, 2,450ft.





Airliners of the World

PROJECTS

AGUSTA A.Z.-8

THE Italian Agusta company are still actively promoting a family of related light transports under this general designation. All employ the same design of unpressurized fuselage for up to 24 passengers but the low-mounted wing can carry different forms of powerplant. It is probable that, should the company decide to finance a prototype, the engines would be Alvis Leonides, four of which would be used. Cruising speed with these engines is calculated as 230 m.p.h.

ARMSTRONG WHITWORTH

LAST September this member of the Hawker Siddeley Group displayed a model of a transport powered by a battery of turbojets—five Sapphires were specified—at the tail of the fuselage. The wing was a superficially conventional low-mounted swept surface, with quite a low aspect ratio. The design gross weight appeared to be about 200,000 lb, and the designation was A.W.167.

UNIVERSAL DEVELOPMENT

THE firm of Blackburn and General Aircraft have made, and are making, investigations into the characteristics of developments of the Universal with turboprop power. Three suitable engines are the Bristol Orion, Napier Eland and Rolls-Royce Tyne, and their very high power would allow not only a marked improvement in all aspects of performance but also a substantial increase in payload. For the fullest advantage to be taken of the new engines some alterations to the airframe would be required.

BOEING MEDIUM-RANGE TRANSPORT

FOR upwards of a year the Boeing Airplane Company has been at work on a number of projects for jet transports substantially smaller than the 707 family.

Late in May the senior vice-president, Wellwood E. Beall, announced that the work was aimed at meeting requirements for stage-lengths from as low as 150 up to 1,700 statute miles; he said that the aircraft would probably have four engines, would seat from 40 to 60, would cruise at 550 to 600 m.p.h. and would be in the weight-bracket 60,000 to 140,000 lb—markedly smaller than the Convair Skylark and rather smaller than the Douglas 1925. The vice-president, engineering, Edward C. Wells, added: "Availability of suitable engines is a key point in determining whether a useful and economical airplane can be offered in the near future on a firm basis and whether sufficient air-line interest can be developed to make the project feasible. Such a project could be begun in the near future and the transport could be offered for airline operation beginning in 1961."

BRITANNIA DEVELOPMENTS

IN the Britannia, Bristol have a transport with a greater work-capacity than anything else at present flying and available for purchase. Already the design has been substantially "stretched," yet there remains a considerable untapped potential which Bristol intend to exploit to the utmost. The following is a rough outline of the company's plans in this regard; type numbers are not mentioned since they have little meaning at this stage.

The first stage in the development is to install the Bristol Orion turboprop. Already subjected to intensive bench-running as a complete powerplant, the Orion will give 5,750 e.h.p. under all take-off conditions of altitude and temperature, and its economical cruising power of some 3,000 h.p. at 36,000ft is substantially higher than that of any other shaft-driving commercial engine, being 50 per cent greater than that of the Proteus. B.O.A.C. have already bought 60 Orions for retroactive installation in their Britannia 312s between three and four years hence. The new engine results in a great improvement in every aspect of the Britannia's performance.

Another stage in development which is looked upon as virtually certain is the increase in fuselage length by adding a section 120in long—probably all ahead of the wing. This will allow the payload and weight to be markedly increased. Special versions of the Britannia tailored to the requirements of short and medium stages are now being prepared; they would seem to be particularly well suited to such an alteration.

At present the Britannia is Mach-limited, so it is logical that Bristol should raise the critical Mach number by extending the leading edge of the wing inboard of the inner engines to have considerably greater chord; alternatively, if sufficient engineering man-hours were available, it would be preferable to design an entirely new wing. Such a modification could quite readily produce a really fast (450 m.p.h. cruising) transport without sacrificing the Britannia's great range/payload qualities.

The current task for the ultimate development is to formulate the configuration for a completely new "all-can-do" airliner making the fullest possible use of the power of the Orion and embodying every applicable modern aerodynamic and structural advance. This is at present being done, under the type number Bristol 187. It is currently seen as a double-deck, 140-passenger aeroplane weighing 200,000 lb and capable of cruising at 500 m.p.h. If the work required to produce such a machine were shared between Bristol and Short Brothers and Harland—as seems logical—the 187 might be in service by 1963. It would probably have a lower cost per ton-mile than any other airliner.

CANADAIR CL-44

FOR four years the Canadair division of General Dynamics Corporation have been co-operating with what is now Bristol Aircraft in the evolution of aircraft based on the Britannia. Until now the work has centred upon the CL-28, a maritime-reconnaissance machine for the R.C.A.F., with a design weight of some 140,000 lb. It is an extremely well equipped aircraft which differs greatly from the British airliner; in particular it is unpressurized and has Wright Turbo-Compound engines to give great endurance at low altitude. The first is now being erected at Montreal.

Canadair are now studying a transport designated CL-44, which in general will be based upon the CL-28. Initially it is looked upon as a military transport and command vehicle suitable for the R.C.A.F. but its airline potential is obvious. It will be pressurized and will have turboprop power; engines under consideration include the Bristol Proteus and Orion and the Rolls-Royce Tyne. No detail engineering has yet been made public and it is not known whether Canadair will tend to revert to the Britannia or go ahead along a different path.

COMET 5

NO sooner has a good transport aeroplane been marketed than "informed observers" are speculating on a development. The so-called de Havilland Comet 5, although not entirely a figment of the imagination, does not yet exist as a firm project. While it would be surprising if the de Havilland company were not in fact pursuing vigorously the opportunities offered for improving their jet airliner in accordance with the usual development practice, they do not yet wish to be drawn into discussing in which directions their studies are leading.

There have been, however, several reports both in the British Press and abroad claiming the existence of a Comet 5 and associating it with B.O.A.C. The general consensus of opinion is that such an aircraft would be based on the Comet 4 but would have a new design of wing to permit higher cruising speeds and four Rolls-Royce Conway by-pass engines installed in pods. It has been suggested that such a machine could be developed for service early in the 1960s and that this would be done with the backing of B.O.A.C.

D.H.C.4

FOR several years it has seemed logical that de Havilland Aircraft of Canada, Ltd., should produce an enlarged-Otter type of transport which, if not necessarily aimed directly at the present operators of DC-3s, should be capable of meeting their requirements.

It has generally been expected that the result would be virtually a "stretched" Otter, with two engines. This has, in fact, been the case, and a great deal of detail engineering has been completed to produce the finest practicable multi-purpose machine. The D.H.C.4 will have two R-1340s or R-1300s and will seat 25-30.

DOUGLAS MODEL 1925

ALTHOUGH heavily engaged in a multitude of other projects the Douglas Aircraft Company have been drawn—not unwillingly—into the medium-range jet market by the representations of several operators (who are believed to include United Air Lines). Basically, enquiries have been made upon the feasibility of an advanced transport drawing the maximum possible benefit from the huge background of research for the 1881 (DC-8) but engineered and scaled for domestic stages.

For some months, therefore, a small project team have been at work on the 1925—which will almost certainly become known as the DC-9—and have produced an aeroplane roughly of DC-8 shape but only 80 per cent as large, about 64 per cent as large in areas and half as heavy. Owing to the above evidence of the square-cube law the field performance should be exceedingly good. Power is to be provided by four commercial variants of the Pratt and Whitney J52 (a 7,500 lb two-spool high-pressure engine like a scaled-down J57, sponsored by the U.S. Navy and running in pre-production form) or a special development of the Rolls-Royce Avon (presumably a low-consumption Avon in the same thrust bracket).

Owing to the experience of Douglas's DC-8 work (which generally has priority) most of the "thinking time" and detail engineering and accessory development can be eliminated, and production DC-9 aircraft could be made available from 12 to 18 months behind the first DC-8s, at a price of about £1.07m. The following data have not been officially released by the manufacturer but certainly accurately reflect the 1925 as it was in the spring of this year.

Dimensions. Span, 112ft 9¼in; overall length, 118ft 9in; overall fuselage diameter, 130in; gross wing area, 1,790.6 sq ft.

Weights. Maximum landing weight, 106,000 lb; space-limited payload, 20,200 lb or 66 passengers first-class, 23,840 lb or 94 passengers five-abreast; maximum weight, 134,000 lb.

Performance. C.A.R. field length in i.s.a. conditions, 5,800ft (take-off), 5,523ft (landing); cruising speed, 555 m.p.h.; range, 1,770 statute miles.

EAST GERMAN TRANSPORT

AT a conference in East Berlin in April a model was shown of a new design of jet transport, which, according to reports, is now under construction in East Germany.

The wing, which was mounted in the mid position, appeared to have a span of about 100ft and a sweep angle of 30 deg. Under each wing was a podded turbojet similar in size to the engines of the Tu-104. From the general configuration of the aircraft it seemed likely that the undercarriage was of B-47 "bicycle" type. No specific details of the aircraft are forthcoming, but it has been referred to as "a new East German airliner" which will "shortly be in service."

Airliners of the World

PROJECTS

FAIRCHILD M-186

SINCE its first announcement in December 1953 nothing has been heard of this twin-jet transport project, and it is now unlikely to go ahead. The design was that of a high-wing machine with a fuselage seating up to 64. The specified engine was the Wright J67, a derivative of the Olympus, but any 15,000 lb-thrust unit would presumably be adequate. The wings, which carried the engines buried at their roots, were to be fitted with a variety of high-lift devices. The maximum weight and cruising speed were estimated as 75,000 lb and 570 m.p.h.

FAIREY ROTODYNE

DEVELOPMENT of the twin-Eland Rotodyne rotary-wing transport is going ahead under Ministry of Supply contract. A possible civil version might have the following capability: a still-air range of 270 nautical miles cruising at not less than 150 m.p.h., with a load of 11,000 lb carried in 3,300 cu ft of unrestricted interior. For most passenger services a total of 44 persons, with baggage, could be accommodated.

HANDLEY PAGE LAMINAR AIRCRAFT

FOR a considerable period Handley Page have been investigating the practicability of employing some measure of boundary-layer control over the wing of an aircraft. Laboratory work and extensive flight trials with a two-seat Vampire have now produced remarkably encouraging results, and plans—albeit of a general nature—are in hand for a long-range jet transport designed from the outset for such an installation. In our issue of June 15 we published an impression of a projected machine which appeared to be of roughly Vanguard size; as is characteristic of "laminarized" aircraft, the wing was small in relation to the fuselage.

In a recent reference to their work on such aircraft Handley Page said: "Design studies have been made for aircraft which would reap the benefits from a laminar-flow system. They have shown that only by designing for laminar flow from the very start can its advantages be fully realized.

"Owing to reduced drag, smaller and lighter engines can be used and fuel needed is reduced. Two sets of engines are installed. One provides the low thrust required for the cruise. The other, consisting of lightweight high-thrust engines, provides additional power for take-off and climb. This gives a powerplant with a very low total weight.

"Wings can be smaller; the cumulative effect on all-up weight is much greater than the sum of individual savings. An initial weight-saving of 1,000 lb is worth about 5,000 lb on all-up weight for a long-range aircraft. Thus, for a given task a smaller and lighter laminar-flow aircraft can be built; both its initial and operating costs will be lower than those of a comparable conventional aircraft.

"Aircraft designers and operators today are worried by the way in which the size and weight of conventional aircraft increase rapidly if they are designed for long-range flight. Only recently weight increases resulted in the cancellation of orders for a promising military transport. Laminar-flow aircraft built to fly very great distances, however, need to be no heavier than conventional aircraft whose range is much less. For example, if a conventional jet transport is to fly 3,600 nautical miles, it becomes about twice as heavy as one which flies 2,000 nautical miles. But the weight increase of a laminar-flow aircraft for the longer range is only about 42 per cent. And, initially, the laminar-flow airliner which flies 2,000 nautical miles weighs considerably less than the conventional jet aircraft for the same range and payload."

C-130 DEVELOPMENT

IN view of its remarkable combination of speed, range, load and short-field performance, it is to be expected that the Lockheed C-130 transport of the U.S. Air Force will appeal greatly to civil operators. Lockheed are at present in large-scale production with this aircraft at Marietta, Georgia.

Present plans will keep the line entirely military until about 1958 but it is probable that by that year it will have been possible to obtain a C.A.A. certificate; the Allison T56 turboprop is basically similar to the engine of the Electra. Studies show that the C-130 can haul freight at 5.3 cents per short-ton n.m. on a 1,000-n.m. stage, or at 5.9 over 2,000 n.m.

MD-12

DESIGNED by Misztal, the pre-1939 designer for P.Z.L., the MD-12 is a completely new light transport, although its configuration is basically similar to the same designer's C.S.S. series of Dove-like machines. The MD-12 is probably designed to weigh about 20,000 lb and has a low-mounted wing, two radial engines, a nosewheel undercarriage and a "T-tail." It is intended for Polish internal services but no information is available regarding its schedule of development.

SAUNDERS-ROE PRINCESS

THREE complete airframes were built for the Saunders-Roe Princess flying-boat and all are at present laid up, encased in protective "Cocoons," pending the availability of suitable powerplants (the original design installation was ten early Bristol Proteus).

It now seems likely that the Bristol Orion turboprop will be admirably suited to these great aircraft and that, with six Orions, the original design performance could be very comfortably exceeded. Assuming a design power of 5,045 e.h.p. (4,000 s.h.p. plus 2,720 lb thrust), the re-engined Princess could, without extensive airframe modification (other than that needed to accommodate the new engines) achieve the following figures: unstick in 6,720ft at 345,000 lb (30,000 lb up on the original weight), cruise at 311 knots and have a still-air range of 5,250 statute miles with up to 220 passengers. The work of conversion would necessarily be protracted, since it would involve a largely re-engineered wing; but hope remains that this will be done, perhaps in about three years time.

S.E. CARAVELLE DEVELOPMENT

ALTHOUGH no specific details may be published it is known that the basic design of the S.N.C.A.S.E. Caravelle is such as to facilitate the installation of turbojets considerably more powerful than those at present fitted. This involves little more than relocating the units on existing strong frame nearer to the c.g. than those currently used. Advanced designs of Caravelle have been prepared using the late model Olympus, Pratt and Whitney J57 and J75 (JT3C and JT4A) and Conway.

TU-114

AT a recent reception in Moscow, Gen. Nicolai Zakharov, the deputy director of Aeroflot (the Soviet commercial operator), spoke of a new, and very large, four-jet transport which would shortly be "ready" (not necessarily for service). It would, he said, seat up to 180 passengers on two decks, the lower deck having a restaurant and the upper deck 30 berths. The cruising speed would be 570 m.p.h. and the range exceptional; the General's words were: "Moscow to any capital in the world."

During the Soviet Aviation Day celebrations on June 23 it was learned that this aircraft bears the designation Tu-114. No precise details of its layout, size or derivation have been made public but it is not unlikely that it is descended from the large bomber known as "Bison." This machine has a 30-deg-swept wing of some 175ft span, with four large turbojets partially buried at the roots.

VICKERS-ARMSTRONGS MEDIUM-RANGE TRANSPORT

A BRITISH newspaper recently published a report stating that Vickers-Armstrongs were engaged in the basic study of a design for a jet transport of proportions suitable for carrying about 90 passengers on medium-stage routes. The statement is not confirmed by the company, who have at no time made any reference to such a project.

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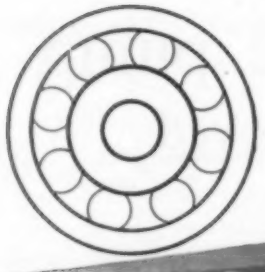

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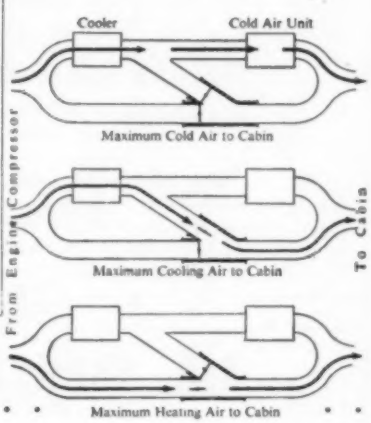
Weight	13 lb. 12 oz.
Nominal bore	4·1"
Material	Light alloy
Operating conditions:	
Through air pressure... ...	50 p.s.i.
Through air temp.	280°C.
Ambient temp. (max.) ...	150°C.
Max. leakage	0·46 lb./min.
Pressure drop across valve:	
	0·55" W.G. at 300 C.F.M. at N.T.P.
	2·9" W.G. at 600 C.F.M. at N.T.P.
No. of ways—IN	TWO
—OUT	ONE
Actuator	Teddington Mk. 2
Time	4-5 min. for full change-over
Voltage	24 V. D.C. nominal
Follow-up resistor	Type FLJ/A/15
Overall dimensions	11·5" x 10·8" x 13·3"

This valve forms part of a Temperature Control System and mixes the supply of hot and cold air to give the desired temperature in an aircraft cabin. It functions in the manner illustrated in the diagram and is capable of modulation between the three positions shown.



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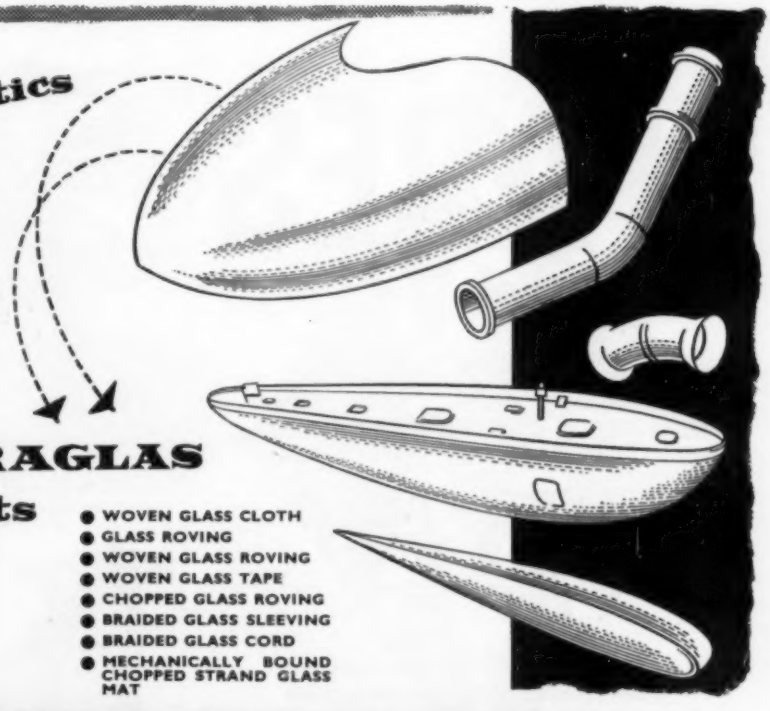

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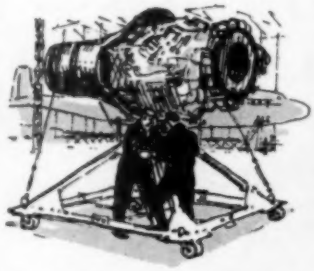

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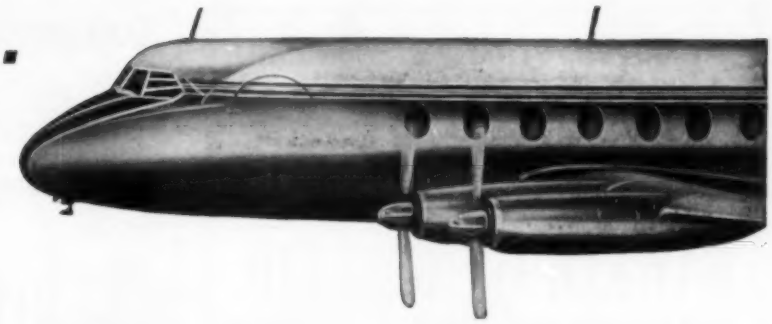

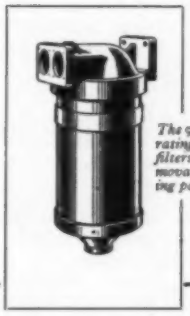

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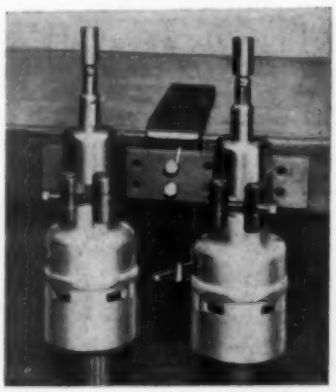

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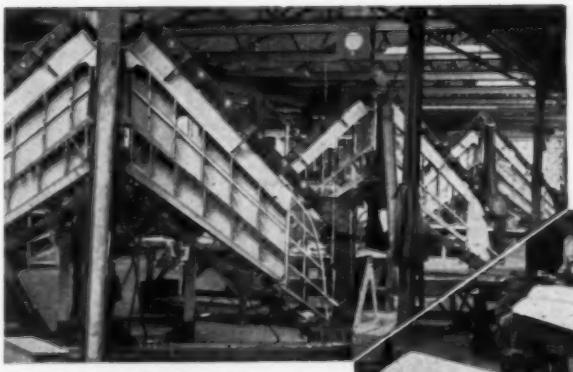

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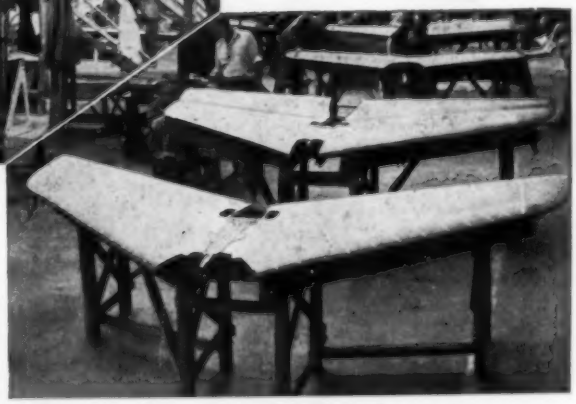

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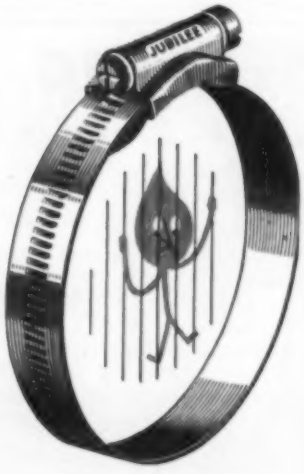

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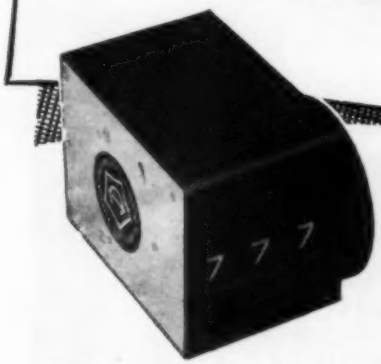

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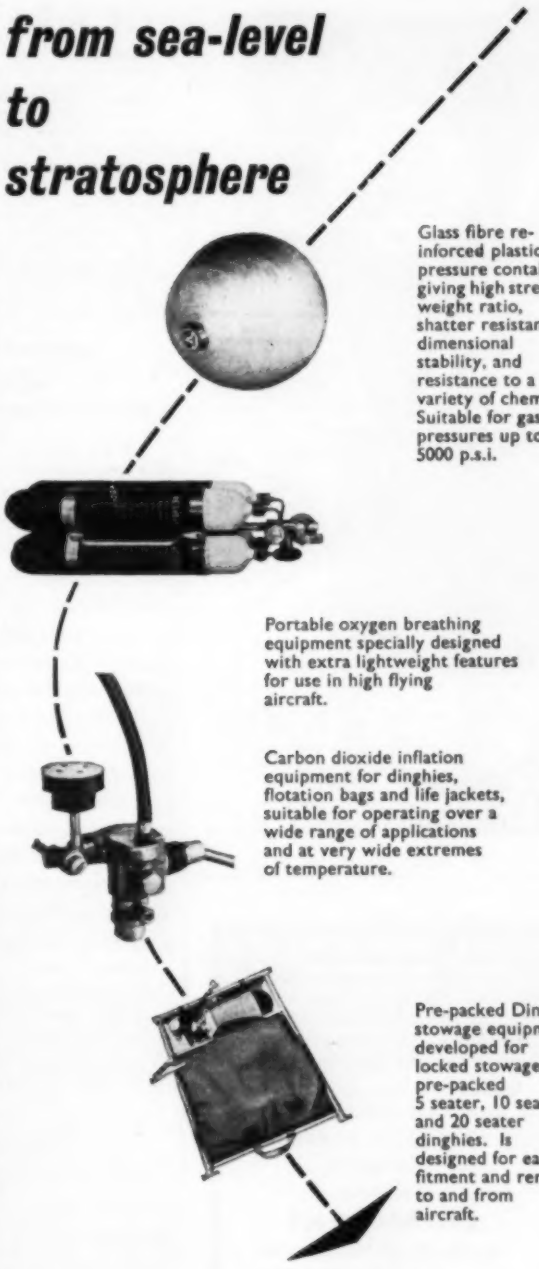

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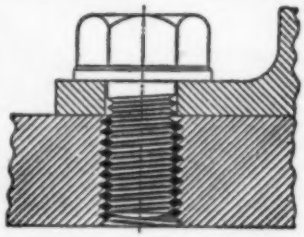

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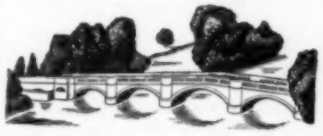
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THE AIR TRANSPORT ADVISORY COUNCIL give notice that they have received the undermentioned applications to operate scheduled air services: —

FROM Derby Aviation, Ltd., Derby Airport, Burnaston, near Derby, for inclusive Tour Services, to be operated with Dakota aircraft, in conjunction with Midland Air Tour Operators:

APPLICATION No. 799, for a service between Birmingham (Elmdon) and Palma, at a frequency of one to two return flights per week, to be operated on Saturdays and/or Sundays, during the season from May to October inclusive, each year, for a period of five years, commencing 1957.

APPLICATION No. 800, for a service between Birmingham (Elmdon) and Perpignan, at a frequency of one to two return flights per week, to be operated initially on Sundays, during the season from May to the middle of October inclusive each year, for a period of five years, commencing 1957.

APPLICATION No. 801, for a service between Birmingham (Elmdon) and Basle, at a frequency of from one to two return flights per week, operated initially on Fridays, during the season from May to September inclusive each year, for a period of seven years, commencing 1957.

APPLICATION No. 802, for a service between Birmingham (Elmdon) and Gibraltar, at a frequency of one return flight per week, operated on Mondays or Tuesdays, during the season from May to the middle of October each year, for a period of five years, commencing 1957.

THESE applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on 30th July, 1952. Any representations or objections with regard to these applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3, Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. [5464

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Quoting Reference AUS/5

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Qualifications: University Honours Degree in Engineering or Science and extensive experience on work related to above-mentioned functions. Experience and control of staff essential.

SENIOR ENGINEER (Temporary Position)

Salary: £1,778/1,943

Duties: V.F.1660, Pt. 2.—Project Engineer—Control of aircraft or weapons sections of prototype design group covering all aspects of airframe design from basic design investigation to protoype design.

Qualifications: University Degree or approved Technical College Diploma in Aeronautical, Civil or Mechanical Engineering or equivalent, with thorough knowledge of military aircraft design. Ability to control design staff. Several years experience in aerodynamics or stressing work is required.

ENGINEER, Grade 3 (Permanent Position)

Salary: £,1443/1,623

Duties: V.P.2559, Pt. 2.—Materials Engineer—Selection and technical control of materials for airframe construction and investigation of defective materials.

Qualifications: University Degree or approved Technical College Diploma in Engineering, Science, Metallurgy or Metallurgical Engineering. Several years experience in Secondary Metallurgy, preferably as related to aluminium and its alloys, required.

ENGINEER, Grade 3 (Temporary Position)

Salary: £1,443/1,623

Duties: V.P.1741. Weight Control and Test Engineer—Weight and centre of gravity estimation, weighing of aircraft, planning of structural test programmes. Compilation of loading sheets for aircraft.

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Salary: £903/1,353

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V.P.2555, Pt. 2.—(One position) Stress analysis of aircraft structures, weight and centre of gravity estimation, analysis of structural tests.

V.P.2557, Pt. 2.—(Two positions) Laboratory and workshop development of new materials and processes and jigging for development purposes. Assessment of such materials for airframe use.

V.P.2560, Pt. 2.—(Two positions) Selection of materials and processes best suited to aircraft production, preparation of technical data and investigating defective materials and processes.

Qualifications: (Eight positions) Appropriate University Degree or approved Technical College Diploma or equivalent qualifications giving full exemption from A.M.I.E. (Aust.) examinations with preferably some experience in relevant fields of work.

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Duties: V.P.2566, Pt. 2.—Supervision of a group of engineers and draftsmen engaged on development and design of electronic equipment for use in guided weapons and radio controlled aircraft including telemetry equipment and systems and flight simulators. Formulating of dynamic and computor equations.

Qualifications: University Degree in Electrical Engineering or Science (Physics) or equivalent qualifications giving full exemption from A.M.I.E. (Aust.) examinations and considerable practical experience with all types of electronic and instrument devices connected with guided missiles.

ENGINEER, Grade 1 (Two Permanent Positions)

Salary: £903/1,353

Duties:

V.P. 2573, Pt. 2.—Assist with design and development of electrical and electronic servo loop mechanisms, computor and magnetic amplifiers and flight simulators. Prepare technical details and specifications for manufacture.

V.P. 2576, Pt. 2.—Assist with development of telemetry and radio control systems including the testing of laboratory equipment and manufacture of prototype equipment. Investigate defects in radio communication equipment.

Qualifications: (Both Positions). Appropriate University Degree or approved Technical College Diploma or equivalent qualifications giving full exemption from A.M.I.E. (Aust.) examinations with preferably some experience in relevant fields of work.

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Duties: V.P.2950. Preparation of drawings and data in connection with the design and development of jet aircraft and guided weapons, in the following categories:

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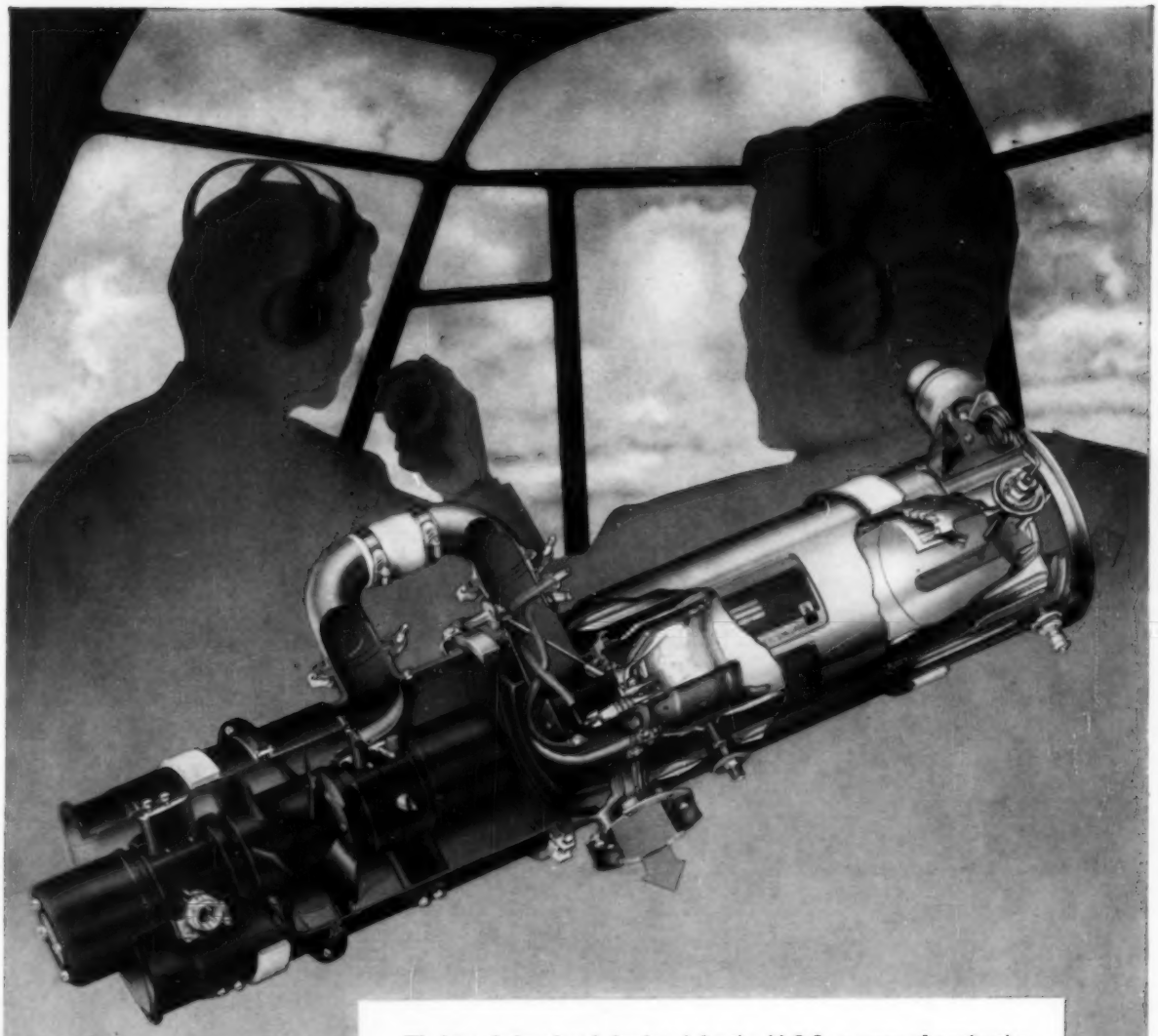

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